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THE ROYAL SOCIETY.

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No. 1.

November 18.

DAVIES GILBERT, Esq. President, in the Chair.

The following Presents were received, and thanks ordered for them :—

Transactions of the Royal Irish Academy, Vol. XVI. Part I. 4to.

—*Presented by the Academy.*

Transactions of the Royal Asiatic Society. Vol. II. 4to.—*The Society.*

Medico-Chirurgical Transactions, published by the Medical and Chirurgical Society of London, Vol. XVI. 8vo.—*The Society.*

The Quarterly Journal of Science, No. 14, New Series. 8vo.—*The Managers of the Royal Institution.*

The Journal of the Royal Institution, No. 1. 8vo.—*The Same.*

The Philosophical Magazine and Annals of Philosophy. By R. Taylor, F.L.S. and R. Phillips, F.R.S. Nos. 43-47. 8vo.—*The Editors.*

The Zoological Journal, No. 18. 8vo.—*The Editors.*

The Edinburgh Journal of Natural and Geographical Science.

Nos. 10-12: with Supplement to No. 12. 8vo.—*The Editors.*

Gill's Scientific, Technological and Microscopic Repository. No. 37. 8vo.—*The Editor.*

Monthly Notices of the Proceedings of the Astronomical Society. Nos. 26-28. 8vo.—*The Society.*

The London Literary Gazette. Nos. 700-721. 4to.—*The Proprietors.*

The National Portrait Gallery of Illustrious and Eminent Personages of the Nineteenth Century. By Wm. Jerdan, Esq. Nos. 15-19. 8vo.—*The Proprietors.*

Astronomical Observations made at the Observatory of Cambridge. Vol. II. (1829).—*Professor Airy.*

Mémoires de l'Académie Royale des Sciences de l'Institut de France, Tome IX.—*The Academy.*

Flora Batava. No. 85-86, 4to.—*His Majesty the King of the Netherlands.*

- Transactions of the American Philosophical Society, held at Philadelphia for promoting Useful Knowledge. Vol. III. Part II. New Series. 4to.—*The Society*.
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- Notice sur le Tettigopsis, nouveau genre d'Orthoptères de la Russie. Par G. Fischer-de-Waldheim. 4to.—*The Author*.

A Paper was read, entitled, "On the nature of negative and imaginary quantities." By Davies Gilbert, Esq. President of the Royal Society.

The object of this paper, the author observes, is one that has given rise to much controversy, and has been involved in much unnecessary mystery. Paradoxes and apparent solecisms, when involved with facts and indubitable truths, will always be found, upon accurate examination, to be near the surface, and to owe their existence either to ambiguities of expression, or to the unperceived adoption of some extraneous additions or limitations into the compound terms employed for definition, and which are subsequently taken as constituent parts of their essence.

The first misapprehension pointed out, is that of considering any quantity whatever as *negative per se*, and without reference to another opposed to it, which has previously been established as *positive*. In order to avoid previously formed associations of ideas, the author prefers employing in his reasonings on this subject, the symbols (*a*) and (*b*) to express this quality of opposition, rather than the usual ones of *plus* and *minus*. By the aid of this notation he is enabled to present, in its full generalization, the law of the signs in multiplication,—a process which, it is well known, is founded solely upon the principle of ratios; and to show that like signs invariably give the sign belonging to the assumed unity, or universal antecedent of the ratios; and unlike signs, the contrary.

Since either the one or the other of the arithmetical scales derived from the two unities is in itself equally affirmative, but negative with relation to the other, it follows, that by using the scale of (*b*), all even roots in the scale of (*a*) will become imaginary, and thus the apparent discrimination of the two scales is removed; so that the properties belonging to the two scales are interchangeable, and all formulæ become universally applicable to both, by changing the signs according to the side in which the universal antecedent is taken. Imaginary quantities, then, are merely creations of arbitrary definitions, endowed with properties at the pleasure of him who defines them; and the whole dispute respecting their essence turns upon the very point that has been contested from the earliest times, between the hostile sects of realists and nominalists.

It is now, however, universally agreed, that all abstractions and generalizations are mere creatures of the reasoning faculty, existing nowhere but in the mind contemplating them. Such, in algebra, are the supposed even roots of a real quantity, taken in the scale opposite to that which has given the universal antecedent: the sign indicating the extraction impossible to be performed, veils the real quantity, and renders it of no actual value until the sign is taken away by an involution, the reverse of the supposed operation which the sign represents; although the quantity itself is, in the mean time, by its arbitrary essence, made applicable to all the purposes for which real quantities are used, in every kind of formula.

Several illustrations of these views of the nature of imaginary

quantities occurring in logarithmic formulæ, and series expressing circular arcs, are given by the author. By considering all quantity as affirmative *per se*, and admitting *plus* and *minus* merely as correlative terms, we thus succeed in banishing mystery and paradox from the science most powerful in eliciting truth, and where they ought least to find a place.

November 25.

DAVIES GILBERT, Esq. President, in the Chair.

The following Presents were received, and thanks ordered for them:—

Transactions of the Plymouth Institution. 8vo.—*Presented by the Institution.*

Illustrations of Indian Zoology; consisting of coloured Plates of new, or hitherto unfigured, Indian Animals, from the collection of Major-general Hardwicke, F.R.S. Selected and arranged by John Edward Gray, folio.—*John E. Gray, Esq.*

Monthly Notice of the Proceedings of the Astronomical Society. No. 29. 8vo.—*The Society.*

Ireland and its Economy; being the result of Observations made in a Tour through the Country in the Autumn of 1829. By James E. Bicheno, Esq. F.R.S. 8vo.—*The Author.*

The Elements of the Theory of Mechanics. By the Rev. Robert Walker, M.A. 8vo.—*The Author.*

The London Literary Gazette. No. 722. 4to.—*The Proprietors.*

An Engraved Portrait of John Dalton, Esq. F.R.S.—*Joseph Allen, Esq.*

Mémoires présentés par divers Savans à l'Académie Royale des Sciences de l'Institut de France, et imprimés par son ordre. (Sciences Mathématiques et Physiques.) Tome deuxième. 4to. 1830.—*The Academy.*

Astronomische Beobachtungen auf der Königlichen Universitäts-Sternwarte in Königsberg. 13 u. 14 Abtheilungen. Von F. W. Bessel, Ritter, u. s. w. folio.—*Professor Bessel, For. Memb. R.S.*

Annalen der K. K. Sternwarte in Wien. Nach dem Befehle Seiner Majestät, auf Oeffentliche Kosten, herausgegeben. Von J. J. Littrow und Lambert Mayer. Zehnter Theil. folio.—*Professor Littrow.*

A Paper was read, entitled, “On a simple electro-chemical method of ascertaining the presence of different metals; applied to detect minute quantities of metallic poisons.” By Edmund Davy, Esq. F.R.S., M.R.I.A., and Professor of Chemistry to the Royal Dublin Society.

The Voltaic arrangement employed by the author consisted merely of small slips of different metals, generally zinc and platina, placed in contact and forming a galvanic circuit with the inter-

posed fluid suspected to contain the poisonous metal; in which case, as was formerly shown by Sir H. Davy in his Bakerian lecture, the metal held in solution is deposited in the form of crystals, on the negative surface. The zinc was usually employed in the form of foil; the platina was, in some cases, a small crucible, or a spatula; but more frequently platina foil was used. It is generally necessary to mix a few drops of acid with the metallic compounds that are subjected to this test, and that are placed in contact with the platina: on applying the zinc foil, the platina will soon become coated with the reduced metal.

The author then enters into the detail of his experiments on the efficacy of his method in the detection of arsenic, mercury, lead and copper, in their different states of oxidation and saline combinations; and of the precautions necessary to be observed in the case of each metal. He was enabled to detect the presence of arsenic, by the exhibition of its characteristic properties, when only the 500dth part of a grain of that metal was deposited on the platina; and in some instances could appreciate the 2500dth part of a grain, by the application of appropriate tests.

The author next ascertained that the electro-chemical method is competent to the detection of very minute quantities of the different metals, when their compounds are mixed with various vegetable and animal substances. Thus, the presence of arsenic would readily be discovered when mixed with all the ordinary articles of diet,—such as wheaten flour, bread, starch, rice, potatoes, peas, soup, sugar, vinegar, gruel, tea, milk, eggs, gelatine, and various kinds of wine; also when mixed with the principal secretions of the alimentary canal, as bile and saliva. Arsenious acid mixed with butter, lard and oils, or with sheep's blood, or ox bile, was detected with great ease. Similar results were afforded by corrosive sublimate, the acetate of lead, and sulphate of copper, added in small quantity to the most complicated mixtures of organic substances. In some instances where the common tests do not act at all, or only act fallaciously, the electro-chemical method acts with the greatest certainty.

Anniversary Meeting, Nov. 30th.

DAVIES GILBERT, Esq. President, in the Chair.

On this occasion the President delivered the following Address:

Gentlemen,

Having now, for the last time, to address you in reference to the loss of eminent persons sustained by the Society in the preceding year, I cannot but congratulate you on the difference between the list now read, and that which we had the misfortune to hear twelve months ago. Several individuals of great distinction, of extensive acquirements and of splendid talents, are undoubtedly brought before us on the present occasion: but advanced age or long absence from

this metropolis tend in some instances to lessen the pain we should otherwise feel on the recital of their names. While in the former case, persons at the very head of different departments in science, of our own ages, and daily conversant with our social habits, were suddenly taken from us, leaving the higher paths of science (as we feared at the time) without a foot that might in future trace their windings; and our more familiar society without that sparkling of intellect, which invigorates the understanding, and at once elevates and refines the common intercourses of life.

The individual, who unquestionably demands our first attention is Major James Rennell, taken from us in his eighty-eighth year, lamented by all those who are capable of appreciating his science, and by every one conversant with his active virtues or with the simplicity and kindness of his manners.

I have endeavoured to collect some particulars respecting this distinguished person in his early years.

Major Rennell was descended from an ancient and respectable family in Devonshire, said to be of Norman origin. His father was a Captain in the Royal Artillery, and fell at the siege of Maestrich. James Rennell was born at his father's house, Upcott near Chudleigh, in Devonshire, on the 23rd of December, 1742. He entered on the naval service of his country at a very early age, where his spirit and exertions soon attracted the notice of Sir Hyde Parker, with whom he sailed in the Brilliant frigate to India. After the conclusion of peace, his eager desire for active service induced him to quit the navy, and he obtained a commission in the corps of engineers belonging to the East India Company. His zeal and ability in discharging the duties belonging to this station obtained for him the friendship of many superior officers, and especially of the great Lord Clive; and he was soon promoted to the station of Surveyor General in Bengal.

The fatigues attached to this civil employment were sufficient to exhaust the strength of any European constitution, conducted as were the surveys, with indefatigable industry, along the banks of the great rivers, periodically overflowed and perpetually damp. But these were not all: Major Rennell in encountering dangers which are inseparable from military renown, had suffered wounds so severe that he was, I believe, twice left exposed on the field of battle, and never recovered from their effects up to the latest period of his life. These altogether compelled his return to England, and alone prevented him from attaining the highest military stations.

Retired to private life, the whole energies of his mind were directed to scientific and literary pursuits. We have, founded on his exertions in India; An Atlas of Bengal.—A Map of the Mogul Empire.—Marches of the Army in India.—A Map of the Peninsula.

But the mental powers of Major Rennell were far from being confined to one region of the world.

We have from his pen a work on the Geography of Africa. And with a vigour of intellect that may well call to our recollection the greatest of the Roman Censors, he acquired at an advanced age a competent

knowledge of Greek for consulting the early writers in that language, and gave to the world, *The Geographical System of Herodotus*, including the Expedition of Darius Hystaspes to Scythia; *The Site of Babylon*; *The Temple of Jupiter Ammon*; *The Periplus of Africa*, &c.; and *A Dissertation on the Locality of Troy*.

The attention of this great investigator of everything connected with the surface of our globe, extended itself from mountains and plains to the waters of the ocean; and produced a most curious investigation of the currents prevalent in the Atlantic, and of accumulations caused by certain winds in the English Channel.

And lastly, I would mention a very ingenious mode of ascertaining distances, and connecting with their bearings the actual localities of spots in the Great Desert, by noting the average rate at which camels travel over those worlds of sand.

This is a very imperfect catalogue of the works published by Major Rennell; and I am happy to add that several more exist in manuscript, destined, we may hope, at no distant time, to appear.

Major Rennell has been honoured by the Copley Medal from this Society; by the Gold Medal from the Royal Society of Literature; he was a Corresponding Member of the Institute of France; and a Member of various other Societies.

Our regret for such a man, exerting his intellectual powers with so much energy and to such useful purposes, throughout the course of a long life, and up to his eighty-eighth year, must always be strong and sincere; but we console ourselves with the reflection that he had attained the utmost ordinary limit of human life, amidst the respect and esteem of all who knew him, and that his memory is revered.

Mr. Chenevix was undoubtedly a man of considerable ability, acquirement and industry. We have from him seven different communications to the *Philosophical Transactions*:

An analysis of the arseniates of copper.—Observations on Dr. James's powders, with a method of preparing a similar substance in the humid way.—Observations and experiments upon oxygenated and hyperoxygenated muriatic acid.—An analysis of corundum.—Observations on the chemical nature of the humours of the eye.—Inquiries concerning the nature of a metallic substance, under the title of Palladium.—On the action of platinum and mercury on each other.

In the latter years of his life, which could not have reached three-score, he appears to have abandoned chemistry, and to have fallen on speculations wholly unworthy of being noticed from this place.

The only remaining individual who has taken a direct active part in our labours, by contributing to the *Transactions*, is Mr. James Lewis Smithson, and of this gentleman I must be allowed to speak with affection. We were at Oxford together, of the same College, and our acquaintance continued to the time of his decease.

Mr. Smithson, then called Macie, and an undergraduate, had the reputation of excelling all other resident members of the University in the knowledge of chemistry. He was early honoured by an intimate acquaintance with Mr. Cavendish; he was admitted into the Royal

Society, and soon after presented a paper on the very curious concretion frequently found in the hollow of bambû canes, named *Tabasheer*. This he found to consist almost entirely of silex, existing in a manner similar to what Davy long afterwards discovered in the epidermis of reeds and grasses.

Mr. Smithson enriched our Transactions with seven other communications:—A chemical analysis of some calamines.—Account of a discovery of native minium.—On the composition and crystallization of certain sulphurets from Huel Boys in Cornwall.—On the composition of zeolite.—On a substance procured from the elm-tree, called *Ulmine*.—On a saline substance from Mount Vesuvius.—Facts relative to the colouring matter of vegetables.

He was the friend of Dr. Wollaston, and at the same time his rival in the manipulation and analysis of small quantities. *Αγαθὴ δ' ἐστὶς ἡδὲ βροτοισιν*. Mr. Smithson frequently repeated an occurrence with much pleasure and exultation, as exceeding anything that could be brought into competition with it,—and this must apologize for my introducing what might otherwise be deemed an anecdote too light and trifling on such an occasion as the present.

Mr. Smithson declared, that happening to observe a tear gliding down a lady's cheek, he endeavoured to catch it on a crystal vessel: that one-half of the drop escaped, but having preserved the other half, he submitted it to reagents, and detected what was then called microcosmic salt, with muriate of soda; and, I think, three or four more saline substances, held in solution.

For many years past Mr. Smithson has resided abroad, principally, I believe, on account of his health: but he carried with him the esteem and regard of various private friends, and of a still larger number of persons who appreciated and admired his acquirements.

Of gentlemen who have not taken a direct share in the labours of this Society, I would notice Mr. Henry Browne.

No one, I believe, was ever more distinguished in the important station of commanding those vessels which secure to England the commerce of nations unknown to former ages; nor did any one more largely contribute towards introducing the modern refinements of nautical astronomy, which skilfully pursued, and under favourable circumstances, determine the place of a ship with greater accuracy, than what in the early part of the last century would have been thought amply sufficient for headlands, roadsteads, or harbours of the first importance. And I cannot omit this opportunity of congratulating all those who addict themselves to astronomical pursuits, or who feel an interest in the perfection of geography and navigation, on the great improvements recently suggested and likely to be made in our national ephemeris; improvements which, in part at least, I hoped to have got adopted twelve years ago: but now under more fortunate auspices I flatter myself that they will be carried into execution, and their practical advantages cannot fail of being very great.

Retired to private life, Mr. Browne usefully amused his declining years by a continuance of his favourite pursuits; and up to the latest

period of his life he patronised, encouraged, and promoted practical astronomy.

Lieutenant-Colonel Mackenzie has, I understand, cultivated science in the East, but no particulars have come to my knowledge.

Sir Lucas Pepys is well known to have attained considerable eminence in his profession.

The Rev. Stephen Weston will long be remembered for his learning, abilities, good-nature, and for his eccentric compositions on various subjects, and in different languages. And for one at least, I may truly say, that it would gratify me to find a more permanent reputation secured for this excellent man, by a collection being given to the public of his numerous *Opuscula*.

The late Duke of Atholl demands also attention, not on account of his high station, but as a patron of science, and especially of that most important, interesting and rapidly improving branch of science, Geology.

Geology, deriving its birth from the continent of Europe, seems to have been drawn to this island by the genius of Dr. Hutton, and here to have grown with the vigour of youth under the fostering hands of many who now hear me, and also of a gentleman to whom the Duke of Atholl afforded every assistance to be derived from his large property, and his extensive influence.

The Duke of Atholl has also at once enriched and decorated his country; and afforded an instructive example to all other proprietors of similar wastes, by clothing tracts of land, incapable of a different cultivation, with the most valuable of the pines. His forests of larch, which have acquired maturity in the course of a single life, promise not merely to supersede the use of foreign deal, but to allow of our reserving the tree always esteemed the peculiar pride and boast of this island, for the construction of ships of war on the largest scale.

Another individual remains, whom no technicality in regard to pursuits can prevent our noticing with honour, on this occasion: whose very deportment indicated the elegance of his mind; and the justness of whose remarks on everything connected with art, gave assurance of the perfection invariably found to exist in all subjects created by the touch of his magic pencil.

Sir Thomas Lawrence stands proudly preeminent among native artists, and perhaps among artists of the whole world, in that department to which he exclusively applied the powers of his genius: nor would, I am persuaded, the great painter of the preceding age have been unwilling to admit him as his equal in the delineation of portraits—not the servile copies of individual features, but poetic likenesses, where every excellence is heightened, where the mind is depicted, and where the particular person seems to embody the class of virtues, of intellectual powers, or of amiable qualities, designating the moral order in which he is arranged.

This constitutes unquestionably a department of historical painting not inferior, perhaps, nor even less difficult of acquirement than the others, where all is imaginary.

The name of Reynolds must, and, for various reasons, ever will stand first on the list of those who have cultivated in this country the whole extent of an art, the most refined, requiring talents the most rare, and at the same time the most delightful of all that have sprung from the human mind;—but that of Lawrence will be hailed by the Academy as their *Spes altera*, and their *Decus gemellum*.

I am not aware of the loss of any Fellow of the Society on our Foreign List.

Gentlemen,

Your Council for the past year have awarded one of the Royal Medals to Dr. Brewster, for his various communications on Light, printed in the last volume of your Transactions.

Unable as we are to investigate the real essences of physical bodies, it is impossible nicely to discriminate their relative importance by observing the external or accidental properties they may assume: but light is so preeminent in all its relations; as the cause of vision; in the rapidity of its flight, or of its vibration; in its connexion with heat; in its adorning everything in nature by a secondary quality;—that no more could be wanting to secure its place at the head of that class of transcendent or imponderable substances, which appear to animate the material world.

Other properties have, however, been recently discovered, not less wonderful than those that were previously known, and which promise to decide the long-agitated question between corpuscular projection and the vibration of a fluid at once inconceivably elastic and rare.

In all these discoveries Dr. Brewster has taken an ample share. And as a public testimony of the sense entertained by the Royal Society of their importance, and of his ability and exertions, I have the honour of presenting to him the Royal Medal.

The discovery of any new elementary substance has ever been deemed an occurrence worthy of being marked by some public declaration of applause.

The ascertaining chlorine to be, in the actual state of our knowledge, one of this class, has justly been considered as among the most brilliant of Sir Humphry Davy's achievements in chemical science. Iodine has been added to the supporters of combustion, occupying, like oxygen and chlorine, the negative extremity of the scale in electro-chemistry.

More recently another substance, apparently intermediate between chlorine and iodine, has been derived from the same source as that yielding the latter,—from the water of the sea; and from its peculiar odour denominated brome, and subsequently bromine. An ample account of the properties distinguishing the substance may be found in a memoir by the discoverer, Mons. Balard of Montpellier, read before the Academy of Sciences, published in the *Annales de Chimie*, vol. xxxii. p. 337, and abridged in the twenty-second volume of the Quarterly Journal of Science, p. 384.

It will be seen by referring to the Second Part of our Transactions for the present year, that Dr. Daubeny has detected bromine in

various springs; and it appears that the action of this substance, on the living system, unites with its chemical qualities in associating it with iodine. So marked and so decisive indeed are its effects, that various medical waters are conjectured to owe their beneficial qualities to the presence, in extremely minute portions, of this elementary body, unknown and unsuspected previously to the researches of M. Balard.

To him, therefore, I am directed by your Council to deliver the other Royal Medal, in testimony of the high respect entertained for his ability, industry, and skill displayed in the discovery of bromine.

The Copley and the Rumford Medals have not been awarded.

The Society next proceeded to the election of the Council and Officers for the ensuing year, when the following were declared to be the lists:—

Council.—Peter Barlow, Esq.; John Barrow, Esq.; William Cavendish, Esq.; Sir Astley Cooper, Bart.; Henry Ellis, Esq.; Michael Faraday, Esq.; Colonel Fitzclarence; Davies Gilbert, Esq.; Captain Henry Kater; Viscount Melville; Sir George Murray, Bart.; Rev. George Peacock; Sir Robert Peel, Bart.; A. Wilson Philip, M.D.; John Pond, Esq.; George Rennie, Esq.; N. Aylward Vigors, Esq.

President: His Royal Highness the Duke of Sussex, K.G.—*Treasurer:* John William Lubbock, Esq.—*Secretaries:* Peter Mark Roget, M.D., and John George Children, Esq.

December 9.

His Royal Highness the Duke of SUSSEX, President, in the Chair.

Henry Percy Gordon, Esq., M.A., and the Rev. John Warren, were elected Fellows.

The following Presents were received, and thanks ordered for them:—

Astronomical Observations made at the Armagh Observatory. By T. R. Robinson, D.D. Vol. I. Part II. 4to.—*Presented by the Rev. Dr. Robinson.*

The Philosophical Magazine and Annals of Philosophy. By R. Taylor, F.L.S. and R. Phillips, F.R.S. No. 48. (Dec. 1830.) 8vo.—*The Editors.*

The Edinburgh Journal of Natural and Geographical Science. New Series. No. 1. (Dec. 1830.) 8vo.—*The Editor.*

Fraser's Magazine for Town and Country. No. 10. (Nov. 1830.)—*The Proprietor.*

The National Portrait Gallery of Illustrious and Eminent Personages of the Nineteenth Century. By Wm. Jerdan, Esq. No. 20. 8vo.—*The Proprietors.*

The British Imperial Calendar for the Year 1831. 8vo.—*John Frost, Esq.*

- Commentarii de Rebus in Scientia Naturali et Medicina gestis.
Vol. 1-37. 8vo. Lipsiæ 1752-1803.
————— Supplementa et Indices. Vol. 1-6. 8vo. 1763-93.—
Sir Thomas Phillipps, Bart. F.R.S.
- Elements of Chemistry, including the recent Discoveries and Doctrines of the Science. By Edward Turner, M.D. F.R.S. 8vo. 1831.—*The Author.*
- On the Natural History of the Vicinity of Stockton-on-Tees. By John Hogg, M.A. 8vo.—*The Author.*
- The Genera and Species of Orchideous Plants. Part I., Malaxideæ. By John Lindley, Esq. F.R.S. 8vo.—*The Author.*
- The Genera and Species of Orchideous Plants, by John Lindley, Esq. F.R.S.; illustrated by Drawings on Stone from the Sketches of Francis Bauer, Esq. F.R.S. Part I. Fructification and Genera. Folio.—*The Authors.*
- Researches about Atmospheric Phenomena. Third Edition, corrected and enlarged, with a Series of Engravings illustrative of the Modifications of the Clouds: to which is added the Calendar of Nature. By Thomas Forster, M.B. 8vo.—*The Author.*
- Sections and Views illustrative of Geological Phenomena. By H. T. de la Beche, Esq. F.R.S. 4to.—*The Author.*
- On the recent Improvements in the Art of distinguishing the various Diseases of the Heart, being the Lumleian Lectures delivered before the Royal College of Physicians in the year 1829. By John Elliotson, M.D. F.R.S. folio.—*The Author.*
- A Letter to Sir James M'Grigor, M.D. F.R.S., on the Sanitary Management of Gibraltar Fever. By David Barry, M.D. 8vo.—*The Author.*
- Medicine no Mystery; being a brief Outline of the Principles of Medical Science: designed as an Introduction to their general Study, as a branch of a liberal Education. Second Edition. By John Morrison, M.D. 8vo.—*The Author.*
- A short Treatise on the Principles of the Differential and Integral Calculus. Part II. By the Rev. Baden Powell, M.A. F.R.S. 8vo.—*The Author.*
- An elementary Treatise on the Geometry of Curves and Curved Surfaces, investigated by the application of the Differential and Integral Calculus. By the Rev. Baden Powell, M.A. F.R.S. 8vo.—*The Author.*
- The London Literary Gazette. Nos. 723-4.—*The Proprietors.*

A Paper was read, entitled, "On the performance of fluid refracting telescopes, and on the applicability of this principle of construction to very large instruments." By Peter Barlow, Esq. F.R.S. Corresponding Member of the Institute of France, of the Imperial Academy of Petersburg, &c.

In the first part of this paper the author adduces proofs of the efficacy of telescopes constructed with fluid lenses, on the principles developed in his two former papers, published in the Philosophical Transactions, in separating double stars, resolving nebulae, and exhibiting

different appearances in the discs of the planets. He institutes, with this view, a comparison between the performance of his telescope of 8 inches aperture and 12 feet in length, with Mr. Herschel's telescope, made with his new 20 inches speculum, and with Sir James South's new refractor, of 12 inches aperture and 20 feet focal length. In Mr. Barlow's telescope γ Persei, which is marked as double in South and Herschel's catalogue, is seen distinctly sextuple. The stars composing σ Orionis, marked in the catalogue as two distinct sets of stars, each triple, are shown in Mr. Barlow's telescope as being both quadruple, with two very fine stars between them. A very fine double star was discovered by Mr. Herschel between the two which compose β Capricorni, and was considered by him as a very severe test: this star is seen distinctly in Mr. Barlow's telescope, but not double.

Messier's 22nd nebula is resolved by Sir James South's telescope into an immense number of brilliant small stars. In Mr. Barlow's telescope the same resolution is effected, though somewhat less completely.

The two last-mentioned instances he considers as affording excellent criteria of the exact limits of the power of the instrument.

Mr. Barlow next examined Jupiter and Mars in order to compare the defining powers of the two instruments. Both these planets were more sharply defined in Sir James South's telescope than in that of the author, but in this respect the superiority of the former instrument was by no means as great as he expected: and in the exhibition of the shadow of one of Jupiter's satellites passing over his disc, there was no apparent difference between the two instruments. When applied to Mars, the former with a power of 1200, the latter with one of 260, the effects were nearly equal.

An experience of three years has not shown the slightest perceptible change in either the quantity or quality of the fluid employed as the lens of the author's three-inch telescope; neither has the glass inclosing it suffered any diminution of its transparency. The author conceives it, therefore, to be sufficiently established, that sulphuret of carbon is capable of supplying all the properties of flint-glass, which are required in the construction of a telescope; and moreover, that in consequence of its high dispersive power, it admits of being placed so far behind the principal lens of plate, or crown-glass, as to require to be only one half of the diameter of the latter. This combination also gives a focal power of one and a half time the length of the tube; and consequently the telescope may be reduced in length to two thirds of that which a glass telescope of the usual construction would require for an equal amount of spherical aberration. In the conclusion of his paper, the author proposes what he considers as a great improvement in the plan of construction for very large telescopes on this principle: it consists in making the object-lenses double, by which their spherical aberration may at once be reduced to about one fourth of its present amount, and will then admit of easy correction by a fluid lens, without requiring the inconvenient curvatures for its surfaces which

are now necessary. This construction will also be attended with the advantage of requiring a much smaller thickness in the plate-glass, and will thus facilitate the selection of proper pieces of glass for being worked into an object lens.

From all these considerations, the author entertains the confident expectation of being able, with proper assistance, to construct a telescope of two feet aperture and 24 feet in length, which would as much exceed the most powerful telescopes of the present day, as these exceed the refractors which existed at the close of the last century.

December 16.

His Royal Highness the Duke of SUSSEX, President, in the Chair

The following Presents were received, and thanks ordered for them:—

Illustrations of Mr. S. Cooper's Surgical Dictionary. Published Monthly. Each Part containing four Lithographic Plates, with Letter-press descriptions, and references to the Text. Parts 1-3. 8vo.—*Presented by the Author.*

Occultations of Fixed Stars by the Moon in November and December, 1830. Computed for Greenwich, by Thomas Henderson, Esq.—*The Astronomical Society.*

The Geographical System of Herodotus examined and explained, by a comparison with those of other ancient Authors, and with modern Geography. With Dissertations on the Itinerary State of the Greeks, the Expedition of Darius Hystaspes, the position and remains of ancient Babylon, the alluvions of the Nile, and Canals of Suez; the Oasis and Temple of Jupiter Ammon, the ancient circumnavigation of Africa, and other subjects of History and Geography. 2nd Edition, revised. By James Rennell, Esq. F.R.S. 8vo.—*Mrs. Rodd.*

Elements of the Economy of Nature, or the Principles of Physics, Chemistry, and Physiology; founded on the recently discovered Phenomena of Light, Electro-Magnetism, and Atomic Chemistry. By J. G. Macvicar, M.A. 8vo.—*The Author.*

Illustrations of the atmospherical Origin of Epidemic Diseases. 2nd Edition. By T. Forster, M.B. 8vo.—*The Author.*

Observations on the Union which has become necessary between the hitherto separated branches of the Medical Profession, and on the Foundation of a Faculty of Medicine. By T. Forster, M.B. 8vo.—*The Author.*

On the Glanders in the Human Subject. By John Elliotson, M.D. F.R.S. 8vo.—*The Author.*

Science without a Head; or the Royal Society dissected. By one of the 687 F.R.S. s s s. 8vo.—*The Author.*

Berliner Astronomisches Jahrbuch für 1832. Mit Genehmigung der Königlichen Academie der Wissenschaften, herausgegeben von J. F. Encke, Königl. Astronom. 8vo.—*Professor Encke, For. Mem. R.S.*

Verzeichniss der von Bradley, Piazz, Lalande und Bessel beobachteten Sterne, in dem Theile des Himmels zwischen $14^{\text{h}} 56'$ bis $16^{\text{h}} 4'$ gerader Aufsteigung, und 15° südlicher bis 15° nördlicher Abweichung, berechnet und auf 1800 reducirt von Herrn Professor Harding in Göttingen.—Auf Veranlassung der Königl. Akademie der Wissenschaften in Berlin. Akademische Sternkarten: Zone xv uhr, Blatt 16. folio.—*Professor Harding, For. Mem. R.S.*

Chart illustrative of the preceding Work.—*The Same.*

Traité Élémentaire de Matière Médicale. Troisième Edition, revue, corrigée, et augmentée. Par J. B. G. Barbier, D.M. 8vo.—*The Author.*

Aperçu du Commerce Français avec tous les Pays du Monde. Par César Moreau, F.R.S.—*The Author.*

Eloge Historique de M. le Marquis De la Place, prononcé dans la Séance publique de l'Académie Royale des Sciences, le 15 Juin 1829; par M. le Baron Fourier. 4to.—*The Academy.*

A Paper was read, entitled, "Researches in Physical Astronomy;" by John William Lubbock, Esq. V.P. and Treasurer of the Royal Society.

The author has shown in a former paper, published in the last part of the Philosophical Transactions for 1830, that the stability of a system of bodies subject to the law of gravitation, is always preserved, provided they move in a space absolutely devoid of resistance. This conclusion results from the analytical expressions for the variations of the elliptic constants in the theory of the Planetary Motions.

In the present paper he extends his researches to the problem of the precession of the Equinoxes, which admits of a similar solution to the former. Of the six constants which determine the position of the revolving body, and the axis of instantaneous rotation, at any instant, three have only periodic inequalities; while the other three have each a term which varies as the time; but from the manner in which these constants enter into the resulting expressions, the equilibrium of the system may be inferred to be stable, as in the former case. By the stability of the system, the author wishes to be understood to mean that the pole of the axis of rotation has always nearly the same geographical latitude, and that the angular velocity of rotation, and the obliquity of the ecliptic vary within small limits; and that its variation is periodical.

The author also gives new methods of obtaining the inequalities of longitude, and the radius vector, in the planetary theory, retaining the square of the eccentricities. When only the first powers of the eccentricities are retained, these expressions admit of simplification. He subjoins as a numerical example, the calculation of the coefficients of two of the inequalities of longitude in the theory of Jupiter disturbed by Saturn; and points out the requisite substitutions for rendering the formulæ applicable to the case of a superior planet disturbed by an inferior planet.

PROCEEDINGS

OF

THE ROYAL SOCIETY.

1830-1831.

No. 2.

December 23.

JOHN W. LUBBOCK, Esq. V.P. and Treasurer, in the Chair.

James Smith, Esq. of Jordan Hill, Glasgow, was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Chemical Manipulation, being instructions to Students in Chemistry on the methods of performing Experiments of demonstration or of research with accuracy and success. New edition.

By Michael Faraday, Esq. F.R.S. 8vo.—*Presented by the Author.*
Experimental Inquiries on Electrical Accumulation. By Wm. Snow Harris, Esq. 8vo.—*The Author.*

On the Utility of Fixing Lightning Conductors in Ships. By W. S. Harris, Esq. 8vo.—*The Author.*

Observationes Astronomicæ in Speculâ Universitatis Litterariæ Fennicæ factæ. Tomus I. Aboæ A. A. 1824, 1825. Universitatis nomine instituit Mag. Fredr. Guil. Aug. Argelander. folio.—*Professor Argelander.*

Astronomische Beobachtungen auf des Herrn Capitain Otto v. Kotzebue zweiten Reise um die Welt in den Landungsplätzen angestellt von E. W. Preuss. Herausgegeben von W. Struve. 4to.—*Professor Struve, Foreign Memb. R.S.*

Recueil de Lectures faites dans la Séance Publique Annuelle de l'Institut Royal de France, du mardi 24 Avril 1827. 4to.—*The Institute.*

Analyse des Travaux de l'Académie Royale des Sciences, pendant l'Année 1828. Partie Mathématique. Par M. le Baron Fourier, Secrétaire Perpétuel. 4to.—*The Academy.*

Partie Physique. Par M. le baron Cuvier, Secrétaire Perpétuel. 4to.—*The Academy.*

Exposé des Recherches faites par ordre de l'Académie Royale des Sciences, pour déterminer les Forces Elastiques de la Vapeur d'Eau à de Hautes Températures. (Par MM. Prony, Arago, Girard, et Dulong.) 4to.—*The Academy.*

Rapport fait à l'Académie Royale des Sciences, par MM. Thenard et Chevreul, sur un Mémoire de M. Férullas, ayant pour titre : *De l'Action de l'Acide sulfurique sur l'alcool et des produits qui en résultent*; imprimé par ordre de l'Académie. 4to.—*The Academy.*

Rapport sur le Prix de Statistique (décerné à l'ouvrage de M. Falret, sur les aliénés, les suicides, et les morts subites). 4to.—*The Academy*.

Eloge Historique de L. F. E. Baron Ramond. Par M. le baron Cuvier. 4to.—*The Academy*.

Eloge Historique de M. Bosc. Par M. le baron Cuvier. 4to.—*The Academy*.

Discours de M. Féletz, Chancelier, prononcé aux Funérailles de M. le baron Fourier. 4to.—*The Academy*.

Discours de M. Girard, Président de l'Académie des Sciences, prononcé aux Funérailles de M. le baron Fourier. 4to.—*The Academy*.

Mémoire Physiologique sur le Cerveau. Par M. Magendie. 4to.—*The Academy*.

A Paper was read, "On the Hour Lines of the Ancients." By W. A. Cadell, Esq. F.R.S.

The hour lines on the sundials of the ancient Greeks and Romans correspond to the division of the time between sun-rise and sun-set into twelve equal parts, which was their mode of computing time. An example of these hour lines occurs in an ancient Greek sundial, forming part of the Elgin collection of marbles at the British Museum, and which there is reason to believe had been constructed during the reign of the Antonines. This dial contains the twelve hour lines drawn on two vertical planes, which are inclined to each other at an angle of 106° ; the line bisecting that angle having been in the meridian. The hour lines actually traced on the dial consist of such portions only as were requisite for the purpose the dial was intended to serve: and these portions are sensibly straight lines. But the author has shown, in a paper published in the Transactions of the Royal Society of Edinburgh, that if these lines are continued through the whole zone of the rising and setting semi-diurnal arcs, they will be found to be curves of double curvature on the sphere. In the present paper the author enters into an investigation of the course of these curves; first selecting as an example the lines indicating the 3rd and the 9th hours of the ancients. These lines are formed by the points of bisection of all the rising and setting semidiurnal arcs; commencing from the southern point where the meridian cuts the horizon, and proceeding till the line reaches to the first of the always apparent parallels, which, being a complete circle, it meets at the end of its first quadrant. At this point the branch of another and similar curve is continuous with it: namely, a curve which in its course bisects another set of semidiurnal arcs, belonging to a place situated on the same parallel of latitude as the first, but distant from it 180° in longitude. Continuing to trace the course of this curve, along its different branches, we find it at last returning into itself, the whole curve being characterized by four points of flexure. If the describing point be considered as the extremity of a radius, it will be found that this radius has described, in its revolution, a conical surface with two opposite

undulations above, and two below the equator. The right section of this cone presents two opposite hyperbolas between asymptotes which cross one another at right angles. This cone varies in its breadth in different positions of the sphere; diminishing as the latitude of the place increases.

The cones to which the other ancient hour lines belong, are of the same description, having undulations alternately above and below the equator; but they differ from one another in the number of the undulations: and some of these require more than one revolution to complete their surface. The properties of the cones and lines thus generated, may be rendered evident by drawing the sections of the cones on the sphere, in perspective, either on a cylindrical or on a plane surface: several examples of which are given in the paper.

January 13, 1831.

JOHN W. LUBBOCK, Esq. V.P. and Treasurer, in the Chair.

The Earl of Selkirk was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Zoological Researches, and Illustrations; or Natural History of Non-descript, or imperfectly known, Animals, in a Series of Memoirs. Illustrated by numerous Figures. By John V. Thompson, Esq. Vol. I. Part I. 8vo.—*Presented by the Author.*

The Philosophical Magazine and Annals of Philosophy. By R. Taylor, F.L.S. and R. Phillips, F.R.S. No. 49. 8vo.—*The Editors.*

Notice of the Proceedings of the Astronomical Society. No. 30. 8vo.—*The Society.*

Occultations of Planets and Fixed Stars by the Moon, in the year 1831. Computed for Greenwich by T. Henderson, Esq. 8vo.—*The Astronomical Society.*

The National Portrait Gallery. By Wm. Jerdan, Esq. No. 21. 8vo.—*The Proprietors.*

The Life of Sir Humphry Davy, Bart. LL.D. late President of the Royal Society. By John Ayrton Paris, M.D. F.R.S. 4to.—*The Author.*

An Experimental Enquiry into the Number and Properties of the Primary Colours, and the source of Colour in the Prism. By Walter Crum, Esq. 8vo.—*The Author.*

A Dissertation on the component Parts of an Animal Body. By H. W. Dewhurst, Esq. 12mo.—*The Author.*

A Synoptical Table of an improved Nomenclature for the Sutures of the Cranium. By the Same. 4th Ed. 12mo.—*The Author.*

Remarks in Reply to a Pamphlet by Nicholas H. Nicolas, Esq., entitled, "Observations on the State of Historical Literature." By Francis Palgrave, Esq. F.R.S. 8vo.—*The Author.*

Das Verhältniss der chemischen Verwandtschaft zur galvanischen Elektricität, in Versuchen dargestellt. Von N. W. Fischer, M. et Phil. Doct. 8vo.—*The Author.*

The reading of a Paper, entitled, On the Equilibrium of Fluids; and the Figure of a Homogeneous Planet in a Fluid state. By James Ivory, Esq. M.A. F.R.S.—was commenced.

January 20.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX,
President, in the Chair.

William John Blake, Esq. M.A. was elected a Fellow.

The following Presents were received, and thanks ordered for them:—

Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce, for the year 1829. 8vo.—*Presented by the Society.*

Proceedings of the Committee of Science and Correspondence of the Zoological Society of London. (Nov. 9, to Dec. 4, 1830.) 8vo.—*The Society.*

On the Probable Connection of Rock Basins, in Form and Situation, with an internal Concretionary Structure in the Rocks on which they occur: introduced by Remarks on the alleged Artificial Origin of those Cavities. By E. W. Brayley, Jun., Esq. 8vo.—*The Author.*

Tabulæ Regiomontanæ Reductionum Observationum Astronomicarum ab Anno 1750 usque ad Annum 1850 computatæ. Auctore F. W. Bessel. 8vo.—*The Author.*

The reading of Mr. Ivory's Paper was resumed and concluded.

The author considers the essential property of a fluid, and that on which its definition should be founded, as consisting in the perfect mobility of its particles among one another. If abstraction be made of the force of gravity, or other accelerating force, when a continuous fluid is at rest, and consequently in a state of equilibrium, all its particles are equally pressed in every direction, are equally distant from one another, and are similarly arranged about every interior point. No fluid is absolutely incompressible; but the degree of compressibility may be conceived to be so small as not to affect the results; and it is accordingly disregarded in the investigations which occupy the present paper.

These investigations are built on the assumption that the hydrostatic pressure at every point of the fluid is the same function of the three rectangular co-ordinates of the point drawn to three planes intersecting one another at right angles. The author shows that the algebraical expressions of the accelerating forces producing the pressure are not entirely arbitrary; because they must necessarily be equal to the partial differential co-efficients of a function of three independent variables, and therefore they are likewise the same func-

tions of the co-ordinates of their point of action in every part of the mass. This is one of the conditions required for the equilibrium of a mass of homogeneous fluid; and a second necessary condition is, that these functions of the ordinates are capable of being integrated. When these two conditions are fulfilled, the determination of the figure of equilibrium is reduced to a question purely mathematical. For we can form an equation expressive of an equilibrium between the accelerating forces and the variation of pressure, and by integrating this equation we may obtain the hydrostatic pressure; whence may be deduced the equation of all those points at which there is no pressure, that is, of the outer surface of the fluid. All that is then requisite for securing the permanence of the figure of the fluid, is that the pressures propagated through the mass be either supported, or mutually balance one another. The upper surface, which is at liberty, and where there is no pressure, and all interior surfaces, where the pressure is constant, have the same differential equation; and from this the author infers that such surfaces are perpendicular to the resultant of the accelerating forces acting upon the particles contained in them. These interior surfaces were denominated by Clairaut *level surfaces*; and they are distinguished by the two properties of being equally pressed at all their points, and of cutting the resultant of the forces at right angles.

The author next extends the investigation to heterogeneous fluids, the different parts of which vary in their density, and deduces a similar conclusion to the former with respect to the perpendicularity of the interior level surfaces to the resultant of the accelerating forces, which act upon the particles situated in each surface respectively. He discusses the hypothesis of Clairaut, of narrow canals traversing the mass in various directions, and shows that the same results follow from it as from the general theory.

The conditions laid down by Clairaut, and all other authors, as those which are necessary for the equilibrium of a homogeneous fluid, are these two:—first, the accelerating forces must be expressed by the partial differential co-efficients of a function of three independent co-ordinates; secondly, the resultant of the forces in action at the upper surface at liberty must be perpendicular to that surface. The author shows that the second condition is a consequence of the first; and he states the independent conditions of equilibrium to be these:—first, the expressions of the forces must be the same functions of the co-ordinates in every part of the mass; secondly, the same expressions must be the partial differential co-efficients of a function of three independent co-ordinates.

In a very extensive class of problems, the difference in the two ways of laying down the conditions of equilibrium disappears. But the theory of Clairaut cannot be extended to the cases in which the particles mutually attract or repel one another, or where the accelerating forces depend on the figure of the mass of fluid. Such is the condition of a homogeneous planet in a fluid state, in which there are forces which prevail in the interior parts, but vanish at the surface; and which are, therefore, not taken into account in Clairaut's theory. But since

these forces tend to change the figure of the fluid, that theory is inadequate to give an exact determination of the equilibrium in those cases.

In the second part of the paper, the author applies his theory of the equilibrium of fluids to the determination of the figure of the planets, under the supposition that they are composed wholly of fluid materials. For this purpose he first considers the problem of determining the equilibrium of a homogeneous mass of fluid entirely at liberty, when the accelerating forces are known functions of the co-ordinates at their point of action. In the investigation of this problem, he supposes that the centre of gravity is at rest, and undisturbed by the action of any accelerating force. He then supposes the fluid to be in equilibrium, and that three planes are laid down, intersecting one another at right angles in the centre of gravity of the mass, to which planes the particles of the fluid are referred by rectangular co-ordinates. The algebraical consequences of this supposition are then pursued, the conditions necessary to equilibrium pointed out, and the conclusion deduced, that the resultant of the accelerating forces is perpendicular to the outer surface, and also to the interior level surfaces of the fluid, at every point of which there is the same intensity of pressure. The figure of the fluid being determined, it remains to inquire, whether the equilibrium is secure; and the result of the inquiry furnishes an equation which proves that the particles have no tendency to move, from any inequality of pressure.

A further discussion is entered into in order to prove that the pressures propagated from the surfaces into the interior parts balance and destroy one another, which completely establishes the permanence of the figure of the fluid. It is also shown that the mass of fluid, under these circumstances, has no tendency to turn upon an axis.

To illustrate the foregoing problem, the author applies it to the determination of the figure of equilibrium of a homogeneous mass of fluid entirely at liberty, of which the particles attract one another with a force directly proportional to the distance, at the same time that they are urged by a centrifugal force caused by rotation about an axis.

He then enters upon the investigation of the second problem, in which the law of attraction of the particles is that of the inverse duplicate ratio of the distance; and finally arrives at the conclusion, that the form of the fluid in equilibrium is, exclusively of all other figures, an oblate elliptical spheroid of revolution, and that its axis of rotation is the lesser axis of the spheroid. He also shows that within the spheroid there are no more than two sets of surfaces equally pressed by the action of the exterior fluid; and no more than two different spheroids of equilibrium answering to the same rotatory motion. If the whole spheroid be one of small oblateness, the greatest of the interior surfaces of equable pressure, which is not a level surface, stands upon the equator; and the rest are within this, and are similar to it, and similarly posited. When it is very oblate, the greatest of these surfaces is described about the lesser axis; and the rest are within it, and are similar to it, and similarly posited. The existence

of two sets of interior surfaces, that are equally pressed at all their points by the action of the exterior fluid, is inconsistent with Clairaut's theory, and is a proof of the insufficiency of that theory for determining the figure of a homogeneous planet.

January 27.

GEORGE RENNIE, Esq. V.P., in the Chair.

The following Presents were received, and thanks ordered for them:—

Views of the Pelvis, showing the Natural Size, Form and Relations of the Bladder, Rectum, Uterus, &c. in the Infant and in the Adult; taken from Preparations made for the Museum of the Royal College of Surgeons in Ireland. By John Houston, Esq. folio.—*Presented by the Author.*

An Account of two newly discovered Muscles for compressing the Dorsal Vein of the Penis, in Man and other Animals; and also of a similar Provision for compressing the Veins of the Chameleon's Tongue. By the Same. 8vo.—*The Author.*

Connaissance des Temps pour l'An 1833. 8vo.—*The Board of Longitude of France.*

L'Annuaire pour l'An 1831. 12mo.—*The Same.*

Bulletin de la Société Française de Statistique Universelle. Première Livraison. 4to.—*The Society.*

Statuts, et Liste des Membres, de la Société Française de Statistique Universelle. 8vo et folio.—*The Society.*

A paper was read, On the probable electric origin of all the phenomena of Terrestrial Magnetism; with an illustrative experiment. By Peter Barlow, Esq. F.R.S. Corr. Mem. Inst. France, and of the Imp. Acad. St. Petersburg.

The author begins his paper by a retrospect of the several discoveries on terrestrial magnetism made since the commencement of the present century. Humboldt, by his numerous and accurate observations on this subject, laid the foundation of all the scientific knowledge relating to it, which we hitherto possessed. The task of reducing these observations to definite principles, by subjecting them to calculation, was undertaken by Biot; and the conclusion which he drew from them was, that on the hypothesis of the earth's being a great magnet, the facts would best accord with the supposition that its two poles are coincident, or indefinitely near to each other, at the centre of the globe. The same result was also obtained, though by a different process of reasoning, by M. Kraft of St. Petersburg. It followed as a necessary consequence, that terrestrial magnetism observes a law different from that of a permanently magnetic body, but identical with that of a body in which transient magnetism is excited by induction. The law which obtains in the case of a sphere of iron rendered magnetic by induction was first investigated, in 1829, by Mr. Barlow; and also, by Mr. Charles Bonnycastle, Professor of

Mathematics in the University of Virginia; it has since been amply confirmed by the more elaborate analytical investigations of Poisson. But the result of all these inquiries, instead of affording us clearer notions of the action of terrestrial magnetism, tended rather to perplex and obscure our views respecting its nature and operation.

While our knowledge was in this imperfect and almost retrograde state, a new light broke in upon us in the great discovery of Oersted, which, by disclosing the intimate relation which electricity bears to magnetism, must be regarded as forming a new era in the history of this department of physical science. The operation of the tangential force between a galvanic wire and a magnetic needle was pointed out by the author, in a paper which was read to the Royal Society in the year 1822; and was still more fully examined by M. Ampère, who extended the investigation to the law of the reciprocal action of galvanic currents on one another; and thence deduced a general theory of magnetic action.

Having established the general fact that the magnetism which is induced on an iron ball resides only on its surface, and acts according to the same laws as the magnetic influence of the earth, the author was desirous of ascertaining whether he could succeed in imitating the effects of terrestrial magnetism by distributing galvanic currents round the surface of an artificial globe. This conjecture he put to the test of experiment, by having a hollow wooden globe constructed, sixteen inches in diameter, with grooves cut at all the parallels of latitude distant by 10° from each other. Copper wires were then laid in these grooves, and disposed so as to allow of the transmission of a galvanic current in similar directions through the whole system of these circular wires. This being effected, it was found that a magnetic needle, properly neutralized, so as to be exempt from all influence from the earth, and freely suspended in different situations on the surface of this artificial globe, assumed positions exactly analogous to those of the dipping-needle in different parts of the earth. The author has no doubt that if the electrical currents in this experiment could be increased indefinitely, the apparatus might be made accurately to represent every circumstance of magnetic dip and direction actually observed in nature.

It thus appears that all the phenomena of terrestrial magnetism may be produced by electricity alone: for it is evident, that in place of the needle employed in the experiment above described, the galvanic needle of Ampère might have been substituted, to the complete exclusion of the only magnetic part of the apparatus.

The discovery of Seebeck, that heat applied to a circuit of metallic conductors develops galvanism, and consequently gives rise to magnetic induction, supplies another link in the chain of evidence, that terrestrial magnetism is purely an electrical phenomenon, deriving its origin, during the diurnal revolution of the earth, from the action of the sun's rays on successive portions of its surface, in directions parallel to the equator. The probability, therefore, is now much increased, that magnetism is a quality not essentially distinct from electricity.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1830-1831.

No. 3.

February 3.

GEORGE RENNIE, Esq. V.P., in the Chair.

The following Presents were received, and thanks ordered for them :—

Catalogue of the Hunterian Collection in the Museum of the Royal College of Surgeons in London, Part II.; comprehending the Pathological Preparations in a Dried State. 4to.—*Presented by the College.*

The Journal of the Royal Institution. No. 2. 8vo.—*The Institution.*
The Philosophical Magazine and Annals of Philosophy. No. 50. 8vo.—*The Editors.*

The National Portrait Gallery. No. 22. 8vo.—*The Proprietors.*

A General History of Birds. By John Latham, M.D. F.R.S. In 10 Volumes 4to.—*The Author.*

Index to the General History of Birds. By John Latham, M.D. F.R.S. 4to.—*The Author.*

Account of the “*Traité sur le Flux et Réflux de la Mer*” of Daniel Bernouilli. By John W. Lubbock, Esq. V.P. and Treas. R.S. 8vo.—*The Author.*

Refutation of Mr. Palgrave’s Remarks; with Additional Facts. By N. H. Nicolas, Esq. 8vo.—*The Author.*

A Paper was read, entitled, “On the Lunar Theory.” Communicated by the Rev. Dr. Lardner.

The subject treated of in this paper is introduced by a review of the labours of Clairault, Euler, D’Alembert, and Thomas Simpson. The theories of these eminent men, the author remarks, were very deficient in accuracy, and were not at all adequate, without correction from observation, to the construction of tables. They could serve only to point out the arguments of the equations, and not all even of these. The inequalities of the moon’s motion are investigated by approximating processes, which lead to results more or less accurate, according as the approximations are carried to a greater or less extent. The writers above mentioned had contented themselves with short and easy approximations; and though they had accomplished much, had yet left much more to be done. Subsequently to these, Mayer published an elaborate theory of the moon; but his coefficients required much correction, the results of his computations being in some cases found to differ very widely from observation.

A much greater degree of accuracy was attained by La Place, who bestowed particular attention on the influence of minute quantities in every part of his theory. In the present paper the author has endeavoured to introduce further improvements in the lunar theory, by carrying the approximations considerably further than they have hitherto been made.

In the solutions of the problem given by former mathematicians, the chief obstacle to the attainment of accuracy was the extreme length and labour of the necessary computations. Another object, therefore, which the author has had in view, is to facilitate these computations, and render them less laborious. This he endeavours to effect by the employment of certain artifices, by which the multiplicity of small terms will, with their co-efficients, be reduced within a practicable compass, and their numerical computation rendered less appalling.

The co-efficient of the equation depending on the moon's distance from the sun, affords the means of calculating the sun's horizontal parallax. For this purpose La Place has computed this co-efficient with greater accuracy than the rest; and he makes the sun's parallax nearly $9''$. The author's theory gives it little more than $8\frac{1}{2}''$, which is very near the mean of the various results obtained by the observation of transits. He thinks that there is, therefore, great reason to conclude that its true value is about this quantity.

February 10.

DAVIES GILBERT, Esq. V.P., in the Chair.

Sir Philip de Malpas Grey Egerton, Bart. M.P., was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Proceedings of the Committee of Science of the Zoological Society. No. 2. 8vo.—*Presented by the Society.*

A Compendious Grammar of the Egyptian Language, as contained in the Coptic and Sahidic Dialects; by the Rev. Henry Tattam:—with an Appendix, consisting of the Rudiments of a Dictionary of the Ancient Egyptian Language in the Enchorial Character; by the late Dr. Young. 8vo.—*The Author.*

Recent Experimental Researches in Electro-Magnetism and Galvanism. By William Sturgeon, Esq. 8vo.—*The Author.*

Conformity with the National Church.—An Answer to "Reasons for Non-Conformity," by John Locke, published in a Life of Mr. Locke by Lord King. (Anon.) 8vo.—*The Author.*

Flora Batava. No. 87. 4to.—*His Majesty the King of Holland.*

Nouveaux Mémoires de l'Académie Royale des Sciences et Belles-Lettres de Bruxelles. Tome IV. et V. 4to.—*The Academy.*

Mémoires sur les Questions proposées par l'Académie Royale des Sciences et Belles-Lettres de Bruxelles, qui ont remporté les Prix en 1822-3. Tome IV. 4to.

— en 1824-5. Tome V. 4to.

— en 1826-7. Tome VI. 4to.

— en 1828. Tome VII. 4to.—*The Academy*.

Correspondance Mathématique et Physique, publiée par A. Que-
telet. Tome V. 8vo.

— Livraisons 1 à 6 de Tome VI. 8vo.—*Professor Que-
telet*.

The reading of a Paper, entitled, "On a New Combination of Chlorine and Nitrous Gas." By Edmund Davy, Esq. F.R.S. M.R.I.A. Professor of Chemistry to the Royal Dublin Society. Communicated in a Letter to Davies Gilbert, Esq. late President of the Royal Society;—was commenced.

February 17.

DAVIES GILBERT, Esq. V.P., in the Chair.

The following Presents were received, and thanks ordered for them:—

A Manual of Analytical Chemistry. By Henry Rose, Professor of Chemistry at Berlin. Translated from the German by John Griffin. 8vo.—*Presented by the Publishers*.

Tables of Life Contingencies. By Griffith Davies, Esq. 8vo.—*The Author*.

Caii Plinii Secundi Libri de Animalibus cum Notis Variorum, curante J. B. F. S. Ajasson de Grandsagne. Notas et Excursus Zoologici Argumenti adjecit G. Cuvier. 8vo.—*The Editors*.

Aperçu d'un Ouvrage Analytique. Par M. Decajoul. 8vo.—*The Author*.

The reading of Professor Davy's Paper was resumed and concluded.

In the course of his experiments on a new test for chlorine gas, an account of which was lately read to the Royal Society, the author was induced to examine the gases produced by the mutual action of nitric acid and different chlorides, and also of the nitric and muriatic acids on each other. When fused chloride of sodium, potassium or calcium, in powder, is treated with as much strong nitric acid as is sufficient to wet it, a considerable action takes place: cold is produced, and a gas of a bright reddish or yellowish colour is copiously evolved, which is promoted by applying a gentle heat. This gas, especially in the early stage of the process, appears to be a mixture of chlorine and another gas, distinguished from it by the great facility with which it is absorbed by water. From this circumstance, and from its also exerting a considerable action upon mercury, its properties cannot be satisfactorily ascertained by collecting it in con-

tact with either of these fluids ; but as it is much heavier than common air, the author was enabled to collect it in sufficient quantity for examination, and nearly in a pure state, from a tubulated retort by means of a bent tube reaching to the bottom of small narrow-mouthed bottles, with ground stoppers.

The gas, when thus obtained, is of a pale reddish yellow colour ; has an odour somewhat resembling that of chlorine, though less pungent. From its strong affinity for moisture, it fumes when brought into contact with the air. In its ordinary state of dryness it destroys vegetable colours, readily bleaching turmeric paper : litmus paper, however, is reddened by it before it is bleached. But when carefully dried by means of fused chloride of sodium, it does not affect those substances. This gas does not support combustion ; but the bifluoride of silver explodes in it.

The author next describes its action upon phosphorus, sulphur, antimony, arsenic, bismuth, tin, copper, zinc, iron, lead, gold, silver, platina, mercury, sulphuric ether, alcohol, oil of turpentine, naphtha, concentrated muriatic acid, iodine, and bromine. With hydrogen gas it forms a mixture which explodes when ignited.

The general conclusion which the author draws from his experiments is, that this gas is an actual compound of chlorine and nitrous gas, and he therefore gives it the name of the chloro-nitrous gas. When collected over mercury, one portion of it forms with that metal a white compound, which appears to be a mixture of calomel and corrosive sublimate, whilst the remainder is found to give orange vapours with common air, attended with a diminution of volume, and to be almost wholly absorbed by a recent solution of green sulphate of iron. He also infers that the gas consists of equal volumes of chlorine and nitrous gas, combined together without any condensation, its atomic number being 102. He finds its specific gravity, compared with that of atmospheric air, to be 1.759.

In the mutual decomposition of chloride of sodium and nitric acid, the products appear to be chloro-nitrous and chlorine gases, and nitrate of soda. The author explains the changes which take place in the following manner :—the nitric acid, by its partial decomposition, yields nitrous gas and oxygen : the former unites with part of the chlorine expelled from the chloride of sodium, to form chloro-nitrous gas, whilst the latter combines with the sodium to form soda, which, with the remaining nitric acid, compose nitrate of soda. The remainder of the chlorine mixes with the chloro-nitrous gas.

The author states that the two component gases of the chloro-nitrous gas unite at once when brought into contact, after having been dried in the most careful manner possible ; a fact which is contrary to the opinion generally entertained among chemists.

By passing chloro-nitrous gas through water an acid is obtained, which appears to resemble very closely the common solvent of gold, or *aqua regia*, otherwise called the nitro-muriatic acid. The author here remarks, that if the constitution of the chloro-nitrous gas be such as he has stated, that is, composed of 30 by weight of nitrous gas, and 72 of chlorine, one of its proportionals should decompose

two of water, consisting of 16 oxygen and 2 hydrogen; thus forming 46 nitrous acid, and 74 muriatic acid. But an acid so constituted should be incapable of acting on gold or platina; now the acid resulting from the absorption of chloro-nitrous gas by water has this power.

The author concludes from his experiments, that the power of nitro-muriatic acid in dissolving gold is not owing to the liberation of chlorine, and that muriatic acid may be separated from nitric acid, even when the latter is only half the volume of the former. He regards chlorine and chloro-nitrous gases as the gaseous products arising from the mutual action of strong nitric and muriatic acids on each other. The nitro-muriatic and chloro-nitrous acids strongly resemble each other in their action on platina, though the solvent power of the latter is decidedly greater than that of the former; and the addition of water considerably increases this power in both, probably by counteracting their disposition to assume the elastic state. Both acids form, with different bases, salts which are mixtures of nitrates and chlorides. The principal differences in these acids may arise from their mode of preparation, and is probably due to the want of uniformity in their composition.

February 24.

DAVIES GILBERT, Esq. V.P., in the Chair.

The Bishop of Chichester; John Lee, LL.D.; and Isaac Wilson, M.D.; were elected Fellows of the Society.

The following Presents were received, and thanks ordered for them:—

Memoir of the Life of Thomas Young, M.D. F.R.S.: with a Catalogue of his Works and Essays. 8vo.—*Presented by Mrs. Young.*

An Enquiry respecting the Site of the Battle of Mons Grampius.

By Lieut.-Col. Miller, C.B. F.R.S. 4to.—*The Author.*

An Engraved Portrait of Charles Wilkins, Esq. LL.D. F.R.S. Engraved by J. Sartain from a painting by T. G. Middleton.—

William Marsden, Esq. F.R.S.

Bulletin de la Société Géologique de France. Tome premier. 8vo.—*The Society.*

A Paper was read entitled, “On the Chemical Action of Atmospheric Electricity.” By Alexander Barry, Esq. F.L.S. Communicated by J. G. Children, Esq. Sec. R.S.

A kite was raised in an atmosphere which appeared favourable to the exhibition of electrical phenomena, from an apparatus firmly fixed in the earth, and insulated by a glass pillar. The string to which it was affixed contained a double gilt thread, and was let out to a length of five hundred yards. It was connected with a platina tube passing about half way down a glass tube full of a solution of

sulphate of soda, coloured with syrup of violets, and inverted in a cup containing the same liquid. A similar wire in another tube, also filled with the coloured solution, was placed in communication with the earth, and the fluids in each made to communicate by a bent glass tube passing from one cup to the other. The result of the experiment was, that hydrogen gas and alkali were developed in the first tube, and oxygen gas and acid in the latter.

The reading of a Paper, entitled, "An Account of Operations carried on for ascertaining the Difference of Level between the River Thames at London Bridge and the Sea: and also for determining the Height above the Level of the Sea, &c. of intermediate points passed over between Sheerness and London Bridge." By John Augustus Lloyd, Esq. F.R.S.;—was commenced.

March 3.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX,
President, in the Chair.

The Rev. Robert Walker, M.A. was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Illustrations of Indian Zoology. Part V. Folio.—*Presented by John E. Gray, Esq.*

Illustrations of Mr. Cooper's Surgical Dictionary. Parts IV., V., and VI. 8vo.—*W. P. Cocks, Esq.*

Notice of the Proceedings of the Geological Society. No. 18. 8vo.—*The Society.*

The Philosophical Magazine and Annals of Philosophy. No. 51. 8vo.—*The Editors.*

The Christian's Magazine, or Weekly Miscellany of Religious Essays, Anecdotes, Literature, Biography, Intelligence, and Poetry. No. 1. 8vo.—*The Editor.*

National Portrait Gallery. No. 23. 8vo.—*The Proprietors.*

A Vade Mecum of Morbid Anatomy, Medical and Chirurgical; with Pathological Observations and Symptoms. Illustrated by upwards of Two Hundred and Fifty Drawings. By W. Money. Second Edition. 8vo.—*The Author.*

The reading of Mr. Lloyd's Paper was resumed and concluded.

The author of this paper received directions from the Lords Commissioners of the Admiralty, in February 1830, at the suggestion of the Royal Society, to survey the river Thames, with a view of ascertaining the difference of level between certain parts of it and the mean level of the sea near Sheerness. Having had experience, while employed in a survey of the Isthmus of Darien, of the great

imperfections in the levelling instruments hitherto used, he bestowed great pains in improving the construction of those employed in the present survey; endeavouring to combine the properties of great steadiness and accuracy of motions in azimuth, with increased delicacy in the level, and permanence in the general position of the whole apparatus; and also to increase the power of the telescope. The author then enters into a full description of the improved instruments which he employed, accompanied by drawings.

As soon as he was furnished with the proper means of observing, he commenced his operations at Sheerness in the month of March. The principal object of his commission being to ascertain the heights of different places above the level of the sea, it became necessary, in the first place, to estimate the heights of the tide; and accordingly, having obtained permission from the Admiralty to erect a tide gauge at the Dock Yard at Sheerness, he selected a corner of the boat basin as the most eligible spot for this purpose: having accomplished this object, he next directed his attention to the establishment of a standard mark, from whence, as from a zero point, the levellings might be reckoned. Considerable difficulty was met with in fixing upon a spot in every respect adapted to this object; for all the buildings in the immediate vicinity of the tide gauge appeared to be deficient in the security of their foundation. He at length selected a large block of granite in the southern pier of the entrance to the boat basin. He then caused a block of gun metal, cast for the purpose, two inches and a half square and eight inches long, to be sunk in the centre of the granite, about an inch below the surface, thereby allowing a brass box and cover to be placed over the standard to protect it from injury. In order that there might be a sufficient number of checks to the permanence of this standard mark, the author caused others to be placed in the yard; namely, one near the southern extremity on the wall of the Dock Yard, one at the eastern side of the great basin, and one in a large block of stone resting on the brick-work of the navy wall. As a further means of future verification of this standard level, he had a very large block of granite placed on a slight eminence, two miles and a half to the southward of the Dock Yard, on which there formerly stood the old castle of Queenborough. One of the brass standards being let into the granite, the place was covered over, but marked by a small mound of earth near it, so that it may easily be referred to whenever it may be thought requisite.

From a series of observations made at Sheerness in the years 1827, 1828, and 1829, it is found that the mean high-water spring tides was 26·355 feet, low-water spring tides 8·74; mean 17·649. The mean high-water neap tides 22·656, low-water 11·336; mean 16·993. The mean of the whole period being 17·27.

The author then states the results of the successive levellings he took from Sheerness along the course of the river to London Bridge. On his arrival at Greenwich Hospital, he commenced a set of branch levels from thence to the Royal Observatory, for the purpose of determining its height above the level of the sea,—an operation which

was rendered tedious by the abruptness of the ascent. Having completed these observations, it occurred to the Astronomer Royal that the instruments employed in the survey might be used as a means of verifying the correctness of the horizontal point of the mural circles. The coincidence of the horizontal wires of the two instruments was found to be so nearly perfect, as to agree within a few hundredths of a second. From Greenwich the levelling was continued on the opposite side of the river to different places where tide-registers had been kept. By the kindness of Mr. Lubbock, the author was furnished with the results of twenty-six years' observations on the tides at the London Docks; from which it appears, that the height of mean high-water mark there, above that at Sheerness, is 2.24 feet and the height of spring tide high-water mark 2.03, and of neap tides 2.35. The Trinity mark on the western side of Old London Bridge is 2.16 feet below the north standard mark at Sheerness, and 1.9 foot above the mean spring tide high-water mark at Sheerness.

The author concludes by giving a long catalogue of standard marks and other points of reference between Sheerness and London Bridge, the north standard at Sheerness being taken as the zero point.

In the course of his observations he found reason to believe that the tremulous appearance of the air which has been termed *mirage*, is caused, not so much by evaporation as by the direct effect of the solar rays: for he remarked, that when there was a succession of clouds passing over the sun, the tremor was very great at those times when the sun shone; but the moment the sun was obscured over the whole space between the instrument and the object viewed, the air was perfectly tranquil.

March 10.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX,

President, in the Chair.

Alexander Caldcleugh, Esq. and John Carnac Morris, Esq. were elected Fellows of the Society.

The following Presents were received, and thanks ordered for them:—

An Engraved Portrait of Davies Gilbert, Esq. V.P.R.S. Engraved by Cousins from a painting by Howard.—*Presented by John Guilemond, Esq. F.R.S.*

Notices of the Proceedings of the Zoological Society. (Jan. 25 to Feb. 8, 1831.) 8vo.—*The Society.*

It being stated to the Meeting by the President that Mr. Caldcleugh, elected that evening, was on the point of leaving England for Mexico, and would consequently have no other opportunity during this session of attending for admission, Mr. Caldcleugh was allowed to sign the Obligation in the Charter Book, and was admitted a Fellow of the Society.

A Paper was read, entitled, "Description of a Graphical Register of Tides and Winds." By Henry R. Palmer, Esq., Civil Engineer. Communicated by J. W. Lubbock, Esq. V.P. & Treas. R.S.

The author having long directed his attention to the effects likely to be produced on the tides in the river Thames, in the port of London, by the removal of London Bridge, was desirous of obtaining a series of accurate observations during all the changes of the tides; and for this purpose constructed a machine, which, being acted upon jointly by a time-piece and by a float resting on the water, registered of itself, upon a piece of paper, both the height of the tide, and the direction of the wind.

A number of parallel and equidistant lines, representing feet in height, are engraved and printed on long sheets of paper, the ends of which are joined together until a sufficient length is obtained for the purpose required. This long sheet is wound upon a brass roller, which is placed near the lower part of a cylinder one foot in diameter, so that the paper may pass round it; its contact being preserved by a roller above, pressing upon it by its own weight. On the axis of the cylinder is a toothed wheel, which is acted upon by a clock, producing an equable motion in the cylinder, which is thus made to complete one revolution in six hours. By means of another wheel, at the expiration of every hour a hammer is raised, whose fall strikes on an upright punch connected with a weather-cock on the top of the building; and the figure of an arrow being cut on the lower end of this punch, an impression of the arrow is made upon the paper: as the direction of the arrow always corresponds with that of the wind, the direction of the latter is thus hourly registered.

Immediately over the axis of the cylinder, and parallel with it, is a rack carrying a pencil. The rack is acted upon by a pinion, which receives its motion from the float on the water: so that as the tide rises or falls, the pencil is moved backwards and forwards through a space which bears a determinate ratio to the actual rise or fall of the float: and thus, by the combined motions of the cylinder and of the pencil, the one regulated by the clock and the other by the tide, a line is traced on the paper, giving a representation of both.

The float, which rests on the water, is a hollow plate-iron vessel, suspended by a chain, which passes twice round a light cast-iron barrel, and then descends, having a counter weight attached to it. The float is placed in a well communicating with the river, through a fine wire gauze, which prevents the undulations of the surface from affecting the water in the well.

The author concludes by an account of an application of similar machinery to the determination of the precise times of high water, and the construction of accurate tide tables. He proposes, with this view, an instrument which shall record the height of the tide at every minute, and promises to give to the Society a full description of such a machine when it shall have been completed.

His Royal Highness then addressed the Meeting, informing them that by the express command of His Majesty, He, together with the

Council of the Society, had that morning waited upon His Majesty at St. James's Palace, for the purpose of witnessing the inscribing of the Royal Signature in the Charter Book of the Society, conformably with the intention which His Majesty had been graciously pleased to express through the Right Hon. Robert Peel, the Secretary of State for the Home Department, in answer to an Address presented to His Majesty by the President and Council, in the name of the Society, in the month of July last.

His Royal Highness stated that he on this occasion addressed the King to the following effect :

“ Sire,

“ May it please Your Majesty,

“ The President and Council of the Royal Society, instituted for the promotion of natural knowledge, in obedience to your commands, now appear in Your Majesty's presence, and humbly crave your gracious permission to lay before you the Volume of their Registry for the insertion of your Royal Signature as Patron of their Institution. Under the fostering care of Your Majesty's predecessors this Society has constantly laboured for upwards of one hundred and seventy years in the pursuit of those objects for which it was originally instituted. This further proof of Your Majesty's favour and patronage will give an additional stimulus to our exertions in the promotion of natural knowledge.

“ While we venture once more to return you our most humble and sincere thanks for the assurances it has pleased you, Sire, to give to us of enjoying your Royal Favour, may we be permitted, in unison with all classes of Your Majesty's faithful and loyal subjects, to offer up our most fervent prayer to the Ruler of all Princes and Kingdoms, for the health, the prosperity, and the happiness of our Most Gracious Sovereign, the patron of every charitable, scientific, and liberal institution.”

To this address His Majesty was pleased to return a most gracious answer ; expressing the high sense he had always entertained of the value and importance of science in conducing to the prosperity, the happiness, and the glory of nations,—an opinion which he had been led to form in early life by witnessing, while engaged in the service of his profession in the navy, the immense practical advantages which result from the cultivation of science ; and assuring the Society of his earnest desire to promote their objects and foster their exertions in so excellent a cause as that in which they are engaged ; and of his anxious wish that they should cordially co-operate with the scientific and learned men of other countries in the same laudable endeavours to enlarge the boundaries of human knowledge.

His Majesty signed his name, in a leaf prepared for the purpose, in the Charter Book, as Patron of the Royal Society.

The Members of the Council were then severally presented to His Majesty by His Royal Highness, and had the honour of kissing His Majesty's hand.

His Royal Highness proceeded to state, that himself, attended by the Council, had afterwards the honour of presenting the following Address to Her Majesty, by whom they were most graciously received.

“ To the Queen’s Most Gracious Majesty,

“ May it please Your Majesty,

“ As President of the Royal Society of London for improving natural knowledge, permit me, Madam, on behalf of that body, to lay before Your Majesty an humble but sincere avowal of the deep respect and entire attachment which every Member of our Society entertains for Your Majesty’s most gracious person, for the Royal and illustrious Consort of our beloved and venerated Monarch, His Most Gracious Majesty King William the Fourth.

“ It is not, perhaps, unknown to Your Majesty, that the Society over which I have the honour to preside, was incorporated in the reign of King Charles the Second ; and, by the especial favour of that monarch, it was designated The Royal Society,—a distinction which every succeeding monarch of these realms has been pleased to continue.

“ A sense of duty and gratitude has led us, in the first instance, to offer up our tribute of condolence and congratulation to the King’s Most Excellent Majesty, on the demise of our late revered Sovereign, and upon his own accession to the crown of his ancestors.

“ Having discharged this duty to our Patron, and having just obtained his Royal Signature, we now venture to request Your Majesty’s powerful support and cheering protection ; and that Your Majesty will be graciously pleased to receive us into your Royal Favour. Our humble expectations rest on the ground of public utility. The great object of our Institution has been, and will, we trust, long continue to be, the promotion of natural science in all its branches. With our success in this respect, the prosperity of our common country is closely and indissolubly connected.

“ Accept then, Royal Madam, the assurances of our duty and allegiance ; and suffer us, in conclusion, to express our warmest wishes for Your Majesty’s uninterrupted welfare and peace.

“ May the great Giver of all good pour down his blessings on your royal person ! May it be consistent with the wise and merciful dispensations of his Providence, that, together with Your Majesty, our generous and beloved Sovereign may long continue to watch over the interests, and to direct the labours, of a free, loyal, and united people !”

To which Her Majesty was pleased to return the following most gracious answer.

“ I thank you very cordially for your expressions of affectionate attachment towards myself, and dutiful congratulations towards the King, on his accession to the throne of his ancestors.

“ Firmly convinced as I am that the diffusion of natural science, guarded and protected by religion and morality, must be conducive

to the prosperity of this country, the President and Fellows of the Royal Society may always depend upon my countenance and approbation, as I am convinced they will receive the support and protection of the King."

The Members of the Council were then severally presented to Her Majesty by His Royal Highness, and had the honour of kissing Her Majesty's hand.

March 17.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX,
President, in the Chair.

The Rev. Thomas Smith Turnbull, M.A.; Christopher R. M. Talbot, Esq.; and Henry Fox Talbot, Esq.; were elected Fellows of the Society.

The following Presents were received, and thanks ordered for them:—

The Nautical Almanac and Astronomical Ephemeris for the Year 1833. 8vo. (3 Copies.)—*Presented by the Lords Commissioners of the Admiralty.*

Second Supplement to an Essay on the Theory of Systems of Rays. By W. R. Hamilton, Esq. 4to.—*The Author.*

On the Error of a received Principle of Analysis, respecting Functions which vanish with their Variables. By the same. 4to.—*The Author.*

Address of Earl Stanhope, President of the Medico-Botanical Society, for the Anniversary Meeting, Jan. 1831. 8vo.—*The Author.*

A Catalogue of Books in the Library of the Company of Clock-makers of the City of London. 8vo.—*The Company.*

Kongl. Vetenskaps-Academiens Handlingar, för år 1827. 8vo.
— för år 1828. 8vo.—*The Academy.*

Register öfrer Kongl. Vetenskaps-Academiens Handlingar, ifrån och med 1813, till och med 1825.—*The Academy.*

Årsberättelser om Vetenskapernas Framsteg, afgifne af Kongl. Vetenskaps-Academiens Embetsmän, d. 31 Mars 1828.—*The Academy.*

Memorie della Reale Accademia delle Scienze di Torino. Tomo XXXIV. 4to.—*The Academy.*

Handleiding tot het Vinden der Ware Sterkte van het Acidum Aceticum door vande Digtheid. Na voorafgegane Proeven opgesteld door A. van der Toorn. 4to.—*The Author.*

A Paper was read, entitled, "Proposed Plan for supplying filtered Water to the Metropolis and its Suburbs." By Lemuel Wellman Wright, Esq., Civil Engineer. Communicated by T. J. Pettigrew, Esq. F.R.S.

The author, after giving extracts from the Report of the Commissioners appointed by His late Majesty to inquire into the supply

of water to the metropolis, in support of the practicability of affording a supply of filtered water from the Thames, adequate to the demand, and within reasonable limits in point of expense, proposes his plan of forming a filter under the bed of the river for each Company. He states that the deposit of mud on each side of the Thames does not reach below the low-water mark, and that the bed of the river throughout is generally a clean and strong, though porous gravel. The mud, therefore, will puddle in, and close the pores of the bed of gravel on which it lies, above low-water mark, so that the filtration into the neighbouring wells, the waters of which are remarkably pure, must take place below low-water mark. He therefore proposes to construct a filtering chamber below the bed of the river, from which chamber a main pipe or tunnel must be made for conducting the filtered water into a well on the river side, whence it is to be drawn up by steam power, and distributed to the houses to be supplied, by the mains and branches at present existing.

The filtering chamber and apparatus are to be prepared by erecting a coffer-dam in the river, of sufficient size to inclose the whole of the area required for that purpose. This coffer-dam will require piles of forty-five feet in length. The bed of the river, thus laid dry, is to be dug out, and a bed of brick-work, set in cement, laid down: a floor must then be constructed in the form of an inverted segment of an arch. On the top of the walls of this floor, plates are to be laid, and in the inclosed area, granite blocks placed; upon these again, the girders are to be laid, and over these the joists, which are to support a first layer of large flints. Upon these, successive layers of smaller flints are to be laid, each decreasing in size as they approach the bed of the river. Upon the uppermost of these, a stratum of clean shingle is to be deposited; then a bed of fine and very clean gravel; and lastly a bed of filtering sand, until it arrives within a foot of the bed of the river, which last space must then be filled up with clean gravel; thereby forming a filtering bed of eight feet in depth, the top of which will still be four feet below low-water mark. So that, allowing seven feet for the timbers and brick-work below, and eighteen feet for the rise and fall of the tide, the total depth at high-water will be thirty-seven feet.

The paper is accompanied by a lithographic drawing, which exhibits the several parts of the scheme.

A Paper was read, entitled, "On the Variable Intensity of Terrestrial Magnetism, and the Influence of the Aurora Borealis upon it." By Robert Were Fox. Communicated by Davies Gilbert, Esq. V.P.R.S.

The author gives the results of a series of observations on the vibrations of the magnetic needle, which he undertook last summer, for the purpose of ascertaining whether the intensity of its directive force is affected by the changes in the earth's distance from the sun, or by its declination with respect to the plane of its equator. He observed that the magnetic intensity is subject to frequent variations, which are sometimes sudden, and of short duration. These anoma-

lies he has been unable to refer to any obvious cause, except when they were accompanied by the appearance of the aurora borealis, which evidently affected the needle on many occasions. He also thinks that the vibrations of the needle became less rapid with a moist atmosphere, and more so when it was very dry. Changes of the wind and snow storms appeared also to be attended with fluctuations in the intensity of the magnetism. He endeavoured to ascertain whether there existed any decided and constant difference in the directive force of each pole; conceiving that, on the hypothesis of a central magnetic force, the north pole of the magnet would, in these northern latitudes, be acted upon with much greater energy than the south pole. From his observing that the relative intensity of the two poles is not always the same, he infers the probability of the earth's magnetism being derived from the agency of electric currents existing under its surface as well as above it, and that the rapid fluctuations in its intensity are owing to meteorological changes.

The author is led to conclude that the aurora borealis is an electrical phenomenon, and that it usually moves during the night nearly from north to south, and in an opposite direction during the day; that it is of the nature of positive electricity; and that its elevation above the earth is much greater than a thousand, and perhaps thousands of miles.

PROCEEDINGS

OF

THE ROYAL SOCIETY.

1830-1831.

No. 4.

March 24.

JOHN W. LUBBOCK, Esq. V. P. and Treasurer, in the Chair.

The following Presents were received, and thanks ordered for them :—

Notices of the Proceedings of the Geological Society. No. 19. 8vo.

—*Presented by the Society.*

Historical Researches on the Wars and Sports of the Morgols and Romans ; in which Elephants and Wild Beasts were employed or slain : and the remarkable local agreement of History with the remains of such Animals found in Europe and Siberia. With a Map and ten Plates. By John Ranking, Esq. 4to.—*The Author.*

Historical Researches on the Conquest of Peru, Mexico, Bogotà, Natchez, and Talomeco in the thirteenth Century by the Mongols, accompanied with Elephants ; and the local agreement of History and Tradition, with the remains of Elephants and Mastodontes found in the New World. With Maps and Portraits. By the same. 8vo.—*The Author.*

The Effects of the principal Arts, Trades, and Professions, and of Civic States, and Habits of Living on Health and Longevity. By C. T. Thackrah, Esq. 8vo.—*The Author.*

Cases of Lithotripsy, or Examples of the Stone cured without Incision ; followed by a Description of the First Symptoms of the Disease. By Baron Heurteloup. 8vo.—*The Author.*

A Treatise on the Coco-Nut Tree. By J. W. Bennett, Esq. 8vo.—*The Author.*

Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg. Tome XI. 4to.

VI^{me} Série. (Sciences Mathématiques, Physiques et Naturelles) Tome premier ; 1^{re}, 2^{me}, et 3^{me} livraison. 4to.

VI^{me} Série. (Sciences Politiques, Histoire, Philologie) Tome premier ; 1^{re}, 2^{me}, et 3^{me} livraison. 4to.

Mémoires présentés à l'Académie Impériale des Sciences de St.

Pétersbourg par divers Savans, et lus dans ses Assemblées. Tome premier; 1re, 2me, 3me, et 4me livraison. 4to.—*The Academy*.
 Rapport sur un Voyage dans les Environs du Mont Elbrouz, dans le Caucase. Par M. Kupffer. 4to.—*The Academy*.
 Astronomische Nachrichten. No. 177-193. 4to.—*Professor Schumacher, Foreign Member, R.S.*

A paper was read, entitled "Description of a Mountain Barometer, the column of which is divisible into two portions for safer and more convenient transport." By Mr. Thomas Charles Robinson. Communicated by Captain Henry Kater, F.R.S.

The object of the contrivance described in this paper is to reduce the length of the barometer, when not in use, to one-half the usual length; and to render the position in which it may be carried indifferent. It consists of a glass tube eighteen inches long, cemented into a steel cistern two inches long, and one inch internal diameter, which is furnished with an internal screw, for receiving a hardened steel screw and hemisphere cemented to the end of a syphon tube. The long leg of this tube has an internal diameter of only the six or eight hundredths of an inch, and it is further contracted at the end to the twenty-fifth of an inch, so that no air can pass when the mercury is descending through it. The shorter leg of the syphon has the same bore as the tube.

When the two parts are screwed together, and the whole inverted, the mercury descends from the cistern, fills the long leg of the syphon, and ascends to a certain height in the shorter leg. Any air that may have existed in that part of the cistern which was not occupied by the mercury, is collected in an intermediate space, external to the column of mercury, and therefore can have no influence on the total height of that column, which is determined solely by the pressure of the external atmosphere. On gently reversing the position of the barometer, the mercury will repass from the syphon into the cistern, where it is confined by a stopper, as in a bottle: and may then be carried about in any position in perfect security.

The reading of a paper, entitled "An Account of further Experiments tried at Chatham, for the purpose of obtaining an artificial Water Cement," by Brevet-Colonel C. W. Pasley, of the Corps of Royal Engineers, F.R.S. and Honorary Member of the Institution of Civil Engineers, was commenced.

The Society then adjourned over Easter to the 14th of April.

April 14.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
 President, in the Chair.

Joseph Hodgson, Esq. was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them :—

- Notice of the Proceedings of the Zoological Society. Feb. 22, 1831.
8vo.—*Presented by the Society.*
- The Philosophical Magazine and Annals of Philosophy. No. 52.
8vo.—*The Editors.*
- The Herschelian, or Companion to the Telescope. Part I. By James Holland. folio.—*The Author.*
- National Portrait Gallery. No. 24. 8vo.—*The Proprietors.*
- The Christian's Magazine. Part I. 8vo.—*The Editor.*
- A Concise View of the Origin, Constitution, and Proceedings of the Irish Society. 8vo.—*Henry Schultes, Esq.*
- The Rise, Progress, and present State of Public Opinion in Great Britain, and in other parts of the World. Second Edition. By W. A. Mackinnon, Esq. F.R.S. 8vo.—*The Author.*
- Meeting of the Cultivators of Natural Science and Medicine, at Hamburgh, in September 1830. By James F. W. Johnston, M.A. 8vo.—*The Author.*
- An Experimental Inquiry into the Laws which regulate the Phenomena of Organic and Animal Life. By George Calvert Holland, M.D. 8vo.—*The Author.*
- The Physiology of the Fœtus, Liver, and Spleen. By the same. 8vo.—*The Author.*
- Ornithological Biography, or an Account of the Habits of the Birds of the United States of America: accompanied by Descriptions of the Objects represented in the Work, entitled, The Birds of America; and interspersed with Delineations of American Scenery and Manners. By John James Audubon, Esq. F.R.S. 8vo.—*The Author.*
- Almanaque Náutico y Efemérides Astronómicas para el Año de 1833, calculadas para el Observatorio Real de Marina de la Ciudad de S. Fernando. 8vo.—*His Majesty the King of Spain.*
- Sammlung der vom 8. May 1817 bis 31. December 1827 im k. k. Convikt-gebäude nächst dem Piaristenkollegium auf der Neustadt Prag Nro. C. 856, angestellten astronomischen, meteorologischen und physischen Beobachtungen von C. Hallaschka, Dr. der Phil. u. s. w. 4to.—*The Author.*
- Recherches sur l'Appareil Sternal des Oiseaux, considéré sous le double rapport de l'Ostéologie et de la Myologie; suivies d'un Essai contenant une distribution nouvelle de ces Vertèbres, basée sur la considération de la Forme du Sternum et de ses Annexes. Par M. le Doct. L'Herminier. 2me Ed. 8vo.—*The Author.*

Colonel Pasley's paper was resumed and concluded.

The present paper is occupied with the detail of the experiments made by the author in the prosecution of the object of his former inquiry, already submitted to the Royal Society, into the best means of obtaining an artificial Water Cement. These experiments

were tried on a larger scale than the former, and were applied more especially to the practical purposes of building. He recommends that the cement should not be applied in two coats, the surfaces being less likely to adhere when this is done, than if the whole cement is applied at once. He succeeded in various ways, in forming cements which appeared to be the same, in all their properties, with natural cements: and he has now employed them in buildings on a scale sufficiently extensive, and in situations sufficiently exposed to the weather, to be brought to the test of experience in the course of time. Some experiments were also made by the author, with the view of forming an artificial lithographic stone, by a calcined mixture of chalk and carbonate of magnesia: but their density could not be rendered such as to answer the purpose intended.

On the whole he draws the general conclusion, that in all attempts to imitate the water cements of nature by artificial means, carbonate of lime must be the essential ingredient; next to which in point of importance are silica and alumina. The author succeeded in forming a very good cement by uniting these three ingredients. By the addition of a small proportion either of the protoxide of iron or of the oxides of lead, or of manganese, the qualities of the compound were very much improved; these latter ingredients appearing to produce a more intimate union of all of them, and a more speedy and permanent induration of the mass.

A paper was read, "On the Meteorological Observations made at the Apartments of the Royal Society, during the Years 1827, 1828, and 1829." By J. W. Lubbock, Esq. V.P. and Treasurer of the Royal Society.

The author first inquires into the annual and diurnal variations of the barometer and thermometer, for the determination of which he takes the mean of the observations in each month made at the Apartments of the Royal Society, during the years 1827, 1828, and 1829; and also that deduced from Mr. Bouvard's observations, published in the Memoirs of the French Academy of Sciences. From the table given it would appear that the annual variations are independent of the diurnal variations. A much greater number of observations than we possess at present, made frequently and at stated times each day, are requisite before any very satisfactory conclusion can be deduced as to the influence of the moon on the fluctuations of the barometer. The author, however, has attempted the inquiry, as far as the limited range of the present records will allow, by classifying all the observed heights, corresponding to a particular age of the moon, as defined by her transit taking place within a given half hour of the day; and thence deducing mean results, which are exhibited in tables.

The results afforded by the observations at Somerset House differ widely from those obtained from corresponding observations made at the Paris Observatory. According to the former, the barometer is highest at new and full moons, and lowest at the quadratures the extent of the fluctuations being 0.08 of an inch: ac-

ording to the latter, the contrary is the case, and the extent is only 0.05 of an inch.

Lastly, the author endeavours to ascertain how far the barometer is affected by the direction of the wind, and gives in the form of tables the mean results of observations bearing upon this point. The fluctuation, he observes, due to this, is much greater than that due to any other cause. The barometer is lowest, as might be expected, when the wind is in the rainy quarters of S.W. and W.S.W. There are not yet sufficient data for any general conclusions with regard to the influence of electrical phænomena on the weather.

April 21.

SIR ASTLEY COOPER, Bart. V.P., in the Chair.

Sir Martin Archer Shee, Knt., P.R.A., was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them :—

The Utility of the Knowledge of Nature considered, with reference to the introduction of Instruction in the Physical Sciences into the general Education of Youth. By E. W. Brayley, Jun., Esq. 8vo.—*Presented by the Author.*

On the Occurrence of the Remains of Elephants, and other Quadrupeds, in the Cliffs of Frozen Mud, in Eschscholtz Bay, within Beering's Strait, and in other distant parts of the Shores of the Arctic Seas. By the Rev. W. Buckland, D.D. F.R.S. 4to.—*The Author.*

Bulletin de la Société Française de Statistique Universelle. 2me Livraison. 4to.—*The Society.*

Extrait du Bulletin de la Société Française de Statistique Universelle. Rapport de la Commission à laquelle a été renvoyé l'examen du projet de Souscription proposée par M. J. S. Buckingham pour un Voyage de Circumnavigation et de Découvertes. 4to.—*The Society.*

Journal de l'Académie de l'Industrie Agricole, Manufacturière et Commerciale. No. 1—2. 4to.—*The Academy.*

A paper was read, "On the Errors in the Course of Vessels occasioned by local attraction, with some remarks on the recent loss of His Majesty's ship *Thetis*." By Peter Barlow, Esq. F.R.S., &c.

The author observes that the errors arising from the deviation of the compass produced by the attraction of ships, were formerly much less considerable than at present, from the comparatively small quantity of iron existing in the vessel. The increase of this disturbing force in a modern ship of war is easily accounted for by the immense proportion of iron now employed in its construction,

by the use of iron ballast and iron tanks, of iron knees, iron cables, and above all, of iron capstans, besides various other articles made of the same material, forming altogether a very large and powerful magnetic mass.

The direction and intensity of the deflecting forces thus produced, vary in different latitudes and on different sides of the equator; being greatest in the highest latitudes, where the dip is considerable, and when the ship's course is east or west: and in high southern latitudes, being the reverse of what it is in high northern latitudes. In His Majesty's ship Gloucester, which may be taken as an example, the deviation of the compass in the east and west points was found to be, in the British Channel, $9^{\circ} 30'$: so that after running ten miles, the vessel would be more than a mile and a half to the southward of her reckoning, and so on in proportion as the distances increased. An error of this magnitude, occurring in a narrow channel and in a dark night, were it unknown or disregarded, might lead to the most fatal consequences; and the disaster might perhaps be erroneously ascribed to the prevalence of a powerful current, the existence of which was before unknown.

The Thetis sailed from Rio Janeiro, in December last, with a million of dollars on board, in the finest weather, directing her course to the S.E. The next day, thinking they were clear of land, they tacked, and were sailing at the rate of nine knots, when the first intimation they had of being near land, was the striking of the jib-boom against a high perpendicular cliff, which broke the bowsprit short off, and sent all three masts over the side; thus in a moment bringing utter destruction on this fine vessel and her valuable cargo. The author shows that the deviation of the compass arising from the attraction of the vessel, was exactly of the kind which was likely to occasion this great mistake in the ship's reckoning: for the distance run by the Thetis being about eighty miles, if the local attraction of the vessel had been equal to that of the Gloucester, she would have passed five miles nearer to Cape Frio than her reckoning,—an error quite sufficient to account for the fatal catastrophe. The author hence infers the importance of bestowing more attention than has hitherto been given to the influence of the local attraction of vessels, and to the application of the proper means of correction.

April 28.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,

President, in the Chair.

James Henderson, Esq., His Britannic Majesty's Consul at Bogotá, was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Mémoires de l'Académie Royale des Sciences de l'Institut de France. Tome X. 4to.—*Presented by the Academy.*

Abhandlungen der Königl. Akademie der Wissenschaften zu Berlin. Aus dem Jahre 1827. Nebst der Geschichte der Akademie in diesem Zeitraum. 4to.—*The Academy.*

The Athenæum Journal of English and Foreign Literature, Science, and the Fine Arts. Nos. 166–182. (Jan. to April, 1831.) 4to.—*The Editor.*

A paper was read, "On the Anatomy and Physiology of the Minute and Capillary Vessels." By Marshall Hall, M.D.

The author, considering the minute blood-vessels as *arteries* or *veins*, as long as their subdivisions or junctions are attended with a change in their dimensions, denominates them *capillaries* when no such change occurs. With the aid of an achromatic microscope of Dollond's, he endeavoured to ascertain what differences existed between the systemic and pulmonary circulations, as far as regards these vessels. Dr. Edwards had observed that the batrachian reptiles are speedily killed by immersion in hot water: and the author found that although by plunging any of the animals of that order into water at 120° of Fahrenheit they are speedily deprived of all power of sensation and of motion, yet the action of the heart continues for a very long time, thus affording an opportunity of leisurely observing the phenomena of the circulation, without the infliction of pain, and without any disturbance from the struggles of the animal.

In the fins and tail of the stickleback, the number of the capillary vessels is small, and their distribution simple: the artery runs along the border of each ray till it reaches the extremity, when it is reflected, and becoming a vein, pursues a retrograde course by the side of the artery. This simplicity in the mode of its distribution corresponds with the simple nature of the function of the part, which is merely an instrument for swimming. In the web of the frog's foot, which is adapted to a greater variety of mechanical purposes, the system of blood-vessels is somewhat more complex; the capillaries are more abundant; the arteries, which are nearly equal in number to the veins, pursue a more direct course; and the veins are larger and more tortuous. No pulsatory movement can be perceived in the blood while moving in the capillaries or veins, as long as the circulation is unimpeded and in the natural state. The author was unable to detect any anastomoses between the minute arteries, although they are frequent among the veins, where they give rise to occasional oscillations in the currents of blood flowing through them: neither could he discover any instance, in the web of the frog, of the immediate termination of an artery in a vein. The velocity of the blood is retarded immediately in its passage from the arteries into the capillaries, because the united capacity of the branches is greater than that of the trunk which divides to form them. In the mesentery of the toad, the distribution of the vessels is simple, like that of the fins and tail of a fish.

But in the pulmonary organs, where the purpose to be answered is that of diffusing the blood over the greatest possible extent of surface, the arteries and the veins correspond to each other in all their ramifications, and their adjacent branches generally pursue courses parallel to each other. Their transition into capillaries is effected with fewer subdivisions than in the case of other arteries. No disposition exists among these arteries to form anastomoses with each other, or with the veins; but the intervening spaces are uniformly occupied by a close network of capillary vessels. The lung of the salamander is simply vesicular; that of the frog is cellular, as well as vesicular, and consequently presents greater difficulty in following with the microscope the course of the vessels as they traverse membranes situated in different planes. In the lungs of the frog, the larger vessels pass chiefly on the external surface; but in the toad they follow the course of the internal margins of the vertical meshes. The author concludes from his observations, that the capillaries, properly so called, have no power to contribute to the motion of the blood, and that the capillary circulation depends altogether upon the action of the heart and arteries. In cases of impeded circulation, he observes, the pulsatory movement of the blood may be seen, not only in the arteries, but also in the capillary vessels, and even in the veins.

At nine o'clock, pursuant to the Notice sent to the Fellows according to the Statutes, a ballot was taken for filling three vacancies in the Council occasioned by the resignation of Viscount Melville, K.T., Sir George Murray, G.C.B., and Sir Robert Peel, Bart. Dr. Goodenough and Sir Robert Inglis were appointed scrutators. After examining the Balloting Lists, they reported that John Frederick Daniell, George Dollond, and Charles Konig, Esqrs., were elected Members of the Council.

A Letter from Sir James South to the Treasurer was read, stating, that the Dome of the Building intended for his large Equatorial was nearly completed, and that he would be happy to show it to the Members of the Society any day of the week, between the hours of one and five.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1830-1831.

No. 5.

May 5.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

Charles James Beverly, Esq. was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them :—

Notices of the Proceedings of the Geological Society. No. 20. 8vo.
—*Presented by the Society.*

The Philosophical Magazine. No. 53. 8vo.—*The Editors.*

The National Portrait Gallery. No. 25. 8vo.—*The Proprietors.*

Researches principally relative to the morbid and curative Effects of Loss of Blood. By Marshall Hall, M.D. 8vo.—*The Author.*

Proposal of a Plan for the investigation of the due administration of Blood-Letting. By the same. 8vo.—*The Author.*

On Astronomy, the Magnet, Tides, &c., with engraved Illustrations. By Thomas Hedgcock, R.N. 8vo.—*The Author.*

A paper was read, “On the effect of Water, raised to Temperatures moderately higher than that of the Atmosphere, upon Batrachian Reptiles.” By Marshall Hall, M.D., &c.

Dr. Edwards had found, by a series of experiments, that the batrachian reptiles, when immersed in hot water, live for a shorter time in proportion as the temperature of the water is higher; and that at 108° of Fahrenheit they die almost instantaneously. The author of the present paper observes, that the extinction of life in these cases is owing to a cause of a more immediately destructive agency than the mere suspension of respiration: he finds that if only the head of the animal is placed under water of 120°, the animal struggles, but soon ceases to move; but if the spine as well as the limbs be immersed, convulsions supervene, and the muscles become rigid: in both cases the action of the heart continues. If one of the limbs, which after the extinction of sensibility still remains flexible, be separated from the body, and placed in water of 120°, its muscles contract and become rigid; this effect taking place first in the superficial, and next

in the deep seated muscles. When the nerve, separated from the other parts, was alone placed in hot water, the muscles were not affected: and when the muscles had been made to contract by hot water, they were no longer capable of being affected by irritations applied to the nerve. The heart removed from the body, and placed in hot water, gradually contracted and remained rigid. Hence the author concludes that the death of the animal, when occasioned by the sudden application of heat to the surface, is not owing to asphyxia, but to a positive agency, destroying the functions of the nervous and muscular systems; the muscles of involuntary motion being affected in like manner with those of voluntary motion.

A paper was read, entitled an "Account of a new mode of propelling Vessels." By Mr. Wm. Hale. Communicated by Richard Penn, Esq. F.R.S.

The author ascribes the want of success which has hitherto attended all attempts to propel vessels by a discharge of water from the stern, to the injudicious plan of the apparatus employed, and not to any defect in the principle itself: for he considers that the reaction upon the vessel from which a volume of water is thrown, depends in no degree on the resistance it meets with from the medium into which it is ejected, but simply upon the momentum given to the mass. The author proposes to accomplish the object of propelling water by means of an instrument having the form of an eccentric curve, resembling the spiral of Archimedes, made to revolve on an axis. The resistance offered to the water in which it is immersed results from the different distances of the two ends of the spiral propeller from the axis. This propeller acts in a box having also a somewhat spiral form, and the space between the two ends of the spiral, after describing one turn, is open to allow of the exit of the water driven out by the propeller. The bottom of the box has a circular aperture, of which the radius is equal to the distance of the shorter end of the propeller from the axis. The water within this circle meets with no resistance until it arrives at the line joining the two extremities of the propeller, when it is immediately acted upon by the eccentric curved surface of the propeller.

A paper was read, entitled, "Additional thoughts on the use of the Ganglions in furnishing Electricity for the production of Animal Secretions." By Sir Everard Home, Bart., F.R.S.

The author considering animal heat as depending on the ganglions, infers from the analogy of the structure of the abdominal ganglia with the electrical organs of fishes, that animal heat arises from the electricity supplied by these ganglions.

May 12.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

Captain George William Manby was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them :—

Royal Astronomical Society. Notices of Proceedings. Vol. 2. Nos. 2 and 3. 8vo.

Charter and Bye-Laws, 1831. 12mo.
—*Presented by the Society.*

The Edinburgh Journal of Science. No. 8. New Series. (April 1831.) 8vo.—*David Brewster, LL.D. F.R.S.*

Memoir of the Life and Scientific Labours of the Rev. William Gregor, M.A. By John Ayrton Paris, M.D. F.R.S. 8vo.—*J. G. Children, Esq. Sec. R.S.*

Description of the Skeleton of the Fossil Deer of Ireland, *Cervus Megaceros*. By John Hart, Esq. Second Edition, with an Appendix. 8vo.—*The Author.*

A Key to Bonnycastle's Trigonometry, Plane and Spherical; containing Solutions to all the Problems, with references. 8vo. By Griffith Davies, Esq.—*The Author.*

Recueil de Planches de Pétrifications Remarquables. Par Léopold de Buch. Premier Cahier. folio.—*The Author.*

A paper was read, "On a peculiar class of Acoustical Figures; and on certain forms assumed by groups of particles upon vibrating elastic surfaces." By Michael Faraday, Esq., F.R.S., M.R.I., Corresponding Member of the Royal Academy of Sciences of Paris, &c.

When elastic plates on which sand has been strewed are thrown into sonorous vibrations, the grains of sand arrange themselves in lines which indicate the quiescent parts of the plate, and have been called the nodal lines. This fact was discovered by Chladni, who also observed that the minute shavings cut by the edge of a glass plate from the hairs of the violin bow employed to produce the vibration, collected together on those parts of the plate that were most violently agitated, that is, at the middle of the lines of oscillation, or portions into which the plate is divided by the nodal lines. The same phenomenon is exhibited by lycopodium, or any other very light and finely divided powder. This subject was investigated by M. Savart, who, in a paper read to the Royal Academy of Sciences at Paris in the year 1817, endeavoured to account for this latter class of phenomena by deducing from the primary divisions of the parts of vibrating bodies, certain secondary modes of division, comprising parts that remain horizontal during every stage of

the vibration, and which therefore may admit of the settlement there of light powders, while heavier powders can be stationary only at the points of absolute rest.

This explanation not appearing to the author to be satisfactory, he made a great number of experiments, which are detailed at length in the present paper, showing that the immediate cause of these motions exists in the surrounding medium, and is to be found in the currents arising from the mechanical action of the plate, while vibrating upon that portion of the medium which is in contact with the plate. These currents are directed from the quiescent lines towards those parts where the oscillation is the greatest, and meeting from opposite sides at these central points, thence proceed perpendicularly from the vibrating surface to a certain distance; and finally, receding from each other, return again in a direction towards the nodal lines. The combination of these motions constitutes vortices carrying with them any light particles which may lie in the way of the currents. While in motion, the powders sustained by these vortices appear in the form of clouds, the particles of which have among themselves an intestine motion of revolution, rising in the centre of the heap, and rolling down again on the outer sides. The powders are collected in the same situations on the vibrating plate, although the plate may be considerably inclined to the horizon, and remain there even when the inclination is so great as to prevent grains of sand from resting on the nodal lines. A piece of gold leaf laid upon the plate was raised up in the form of a blister at that part which corresponded with the centre of the clouds, even to the height of one-twelfth of an inch.

On attaching small pieces of card to different parts of the surface of the vibrating plate, the currents of air are modified in various ways, as shown by the different positions of the clouds, and the production of partial accumulations of the powders. When a tuning-fork is made to vibrate, and a little powder of lycopodium is sprinkled over it, the powder collects into clouds on the middle of the upper surface, and also forms heaps along its sides, exhibiting in a striking manner the intestine revolution of their particles. These effects are also well illustrated by vibrating membranes; for which purpose a piece of parchment was stretched, and tied while moist over the mouth of a funnel, and made to vibrate by means of a horse-hair, having a knot at the end, passed through a hole in the centre of the parchment; the hair being drawn between the finger and thumb, to which a little powdered rosin was previously applied. The phenomena were still more conspicuous when the parchment was made to vibrate under a glass plate held near it. When the interval between the membrane and the glass plate was very small, the whole of the powder was sometimes blown out at the edge, in consequence of the vibrating membrane acting as a bellows.

Reasoning from the theory which the author had framed in explanation of these phenomena, he conceived that if the currents were weakened by placing the apparatus in rarefied air, they would no longer be capable of sustaining the light powders, which would

then be collected, like the heavy powders in air, at the nodal lines. In a denser medium, such as water, the reverse should happen; the heavy powders should be carried along by the more powerful currents then produced, and would accumulate in the vibrating parts. All these conclusions were found to be fully verified by actual experiment.

May 19.

JOHN W. LUBBOCK, Esq. M.A., V. P. & Treasurer, in the Chair.

The following Presents were received, and thanks ordered for them:—

The Astronomical Remembrancer. Proposed by Captain W. H. Smyth, R.N., F.R.S.: exhibiting the Magnitude, Declination, Right Ascension, and Passage in mean time over the Meridian, of one Hundred of the Principal Fixed Stars.—*Presented by G. Dollond, Esq., F.R.S.*

A Narrative of a Visit to the Court of Sinde; a Sketch of the History of Cutch, from its first connection with the British Government in India till the conclusion of the Treaty of 1819; and some Remarks on the Medical Topography of Bhooj. By James Burnes, Esq. 8vo.—*The Author; through Joseph Hume, Esq. F.R.S.*
Catalogue of the Library of the Royal College of Surgeons in London. 8vo.—*The College.*

Catalogue of the Contents of the Museum of the Royal College of Surgeons in London. Part III.: comprehending the Human and Comparative Osteology. 4to.—*The College.*

A Cast from the Marble Bust of Michael Faraday, Esq. F.R.S. executed by E. H. Bailey, R.A.—*Richard Hollier, Esq.*

A Portrait of Michael Faraday, Esq. F.R.S. engraved by Cousins from the Painting by Pickersgill.—*Messrs. Colnaghi and Son.*

A paper was read, entitled, “A Table facilitating the Computations relative to Suspension Bridges.” By Davies Gilbert, Esq. V.P.R.S.

The table here communicated is supplementary to those accompanying the paper “On the Mathematical Theory of Suspension Bridges,” which was published in the Philosophical Transactions for 1826, and is deduced from the first of the tables there given; but admits of a far more ready application than the former to all cases of practical investigation. It consists of five columns, exhibiting respectively the deflections or versed sines of the curve; the lengths of the chains; the tension at the middle points, or apices of the curve; the tensions at the extremities; and the angles made by the chains with the horizon at the extremities.

A paper was read, entitled, “Researches in Physical Astro-

nomy." By J. W. Lubbock, Esq. V.P. and Treasurer of the Royal Society.

The first part of this paper relates to the theory of the moon. The method of solution pursued by Clairaut consisted in the integration of differential equations, in which the true longitude of the moon is the independent variable: the time is then obtained in terms of the true longitude; and by the reversion of series, the longitude afterwards obtained in terms of the time. This method is the one adopted by Mayer, Laplace, and Damoiseau. The author has been led, by reflecting on the difficulties of this problem, to believe that the integration of the differential equations in which the time is the independent variable would be at least as easy as the former process; and it would possess the advantage of employing the same system of equations for the moon as for the planets. The lunar theory proposed by the author, and developed in this paper, is an extension of the equations given in his former *Researches in Physical Astronomy*, already published in the *Philosophical Transactions*; by including those terms, which, in consequence of the great eccentricity of the moon's orbit, are sensible; and by suppressing those which are insensible from the great distance of the sun, the disturbing body. He has not yet attempted to obtain numerical results, but proposes at some future time to engage in their computation.

In the second part of the paper, he investigates the precession of the equinoxes, on the supposition that the earth revolves in a resisting medium; an investigation which may also be considered as a sequel to the author's last paper on *Physical Astronomy*. The effects of the resistance of such a medium is to increase the latitude of the axis of rotation (reckoned from the equator of the figure) till it reaches 90° . Such is now the condition of the axis of the earth: but as the chances are infinitely great against this having been its original position, may not its attainment of this position be ascribed to the resistance of a medium of small density acting for a great length of time,—a supposition which may account for many geological indications of changes having taken place in the climates of the earth? The operation of such a cause would be also sensible in the case of comets: and the accuracy with which the eccentricity of the Halleian comet of 1759 is known, would appear to afford a favourable opportunity of verifying this hypothesis.

A paper was read, entitled, "An Account of the Construction and Verification of the Imperial Standard Yard for the Royal Society." By Captain Henry Kater, F.R.S.

The scale of the standard, of which an account is given in this paper, is constructed in a manner described in the *Philosophical Transactions* for 1830. The support is of brass 40 inches long, 17.5 inches wide, and 0.6 of an inch in thickness. A brass plate seven-hundredths of an inch thick was made to slide freely upon the support in a dove-tail groove formed by two side plates, and was then fixed to the support by a screw passing through its middle.

This plate carries the divisions, which are fine dots upon gold discs let into the brass; the scale is divided into inches, and there is one inch to the left of zero, which is subdivided into tenths. The scale is the work of Mr. Dollond. The paper is concluded by an account of the precautions which were taken to ensure the accuracy of the plane surface on which the bar rested, while the comparisons were made with the microscopic apparatus described in the Philosophical Transactions for 1821. The results are given in a table.

A paper was read, entitled, "An Experimental Examination of the Blood found in the Vena Portæ." By James Thackeray, M.D. Communicated by Sir Astley Cooper, Bart. V.P.R.S.

The author, in the course of an inquiry into the properties of the blood, was led to notice some peculiarities in the contents of the vena portæ, and to investigate this subject more minutely. The results of the experiments which he made for this purpose are chiefly the following. The blood contained in the vena portæ is darker than that of the other veins, inclining more to a ruddy hue than to the Modena red. Being less homogeneous, it has the appearance of being less perfectly elaborated. Its specific gravity was found to be very variable, but it is in general less than ordinary venous blood. It coagulates much more quickly, and contains a larger proportion of serum, but a much smaller proportion of albumen, than blood taken from other veins. The serum obtained from it is redder than common serum, in consequence of its retaining much of the colouring matter of the blood: it has also a greater specific gravity, and yields, on exsiccation, a greater weight of solid matter. On the application of heat, it concretes more quickly, but much less completely, than blood from the jugular vein; which peculiarities are attributed by the author to the different state and imperfect formation of the albumen contained in it. The crassamentum of the blood from the vena portæ does not expel its serum so fully as blood from other vessels; but it remains a soft mass, unless artificial means be employed, and it yields a considerably smaller quantity of fibrin.

The Ballot for William Snow Harris, Esq., which should have been taken at this Meeting, was postponed to the next Meeting, in consequence of there not being twenty-one Members present.

The Society then adjourned over Whitsuntide to the 2nd of June.

June 2.

SIR ASTLEY COOPER, Bart. V.P., in the Chair.

William Snow Harris, Esq., and William Wilkins, Esq. R.A., were elected Fellows of the Society.

The following Presents were received, and thanks ordered for them:—

- The Journal of the Royal Institution of Great Britain. No. III. 8vo.—*Presented by the Institution.*
- The Edinburgh New Philosophical Journal, exhibiting a View of the progressive Discoveries and Improvements in the Sciences and the Arts. Conducted by Professor Jameson. Nos. 19 and 20. (Oct. 1830—March 1831.) 8vo.—*Professor Jameson, F.R.S.*
- The Philosophical Magazine and Annals of Philosophy. No. 54. 8vo.—*The Editors.*
- The Englishman's Magazine. No. I. 8vo.—*The Publishers.*
- National Portrait Gallery. Part 26.—*The Proprietors.*
- Library of the Fine Arts, or Monthly Repertory of Painting, Sculpture, Architecture and Engraving. Nos. 1—4. 8vo.—*The Publisher.*
- Two Views of the Clifton Suspension Bridge ; proposed to be erected according to the design, and under the Directions of I. Brunel, Jun. Civil Engineer, F.R.S.—*I. K. Brunel, Esq. F.R.S.*
- A Portrait of the late Dr. Thomas Young, F.R.S., engraved by Turner from the Painting by Sir T. Lawrence.—*Mrs. Young.*
- Criteria for determining in which Version of the Holy Scriptures the original Hebrew Computation of Time is contained ; with the æras of corruption. By J. Cullimore, M.R.S.L. 8vo.—*The Author.*
- A Letter to the Editor of the Edinburgh Review, in Answer to his Criticism on “ A Journal down the river Marañon,” &c.—By H. I. Maw, Lieut. R.N. 8vo.—*The Author.*
- Die Farben. Entdeckungen aus dem Gebiete physikalischer Farbenlehre durch Versuche dargethan. Von Dr. Jacob Roux. Drittes Heft. 8vo.—*The late Author.*

A paper was read, “ On the Caves and Fissures in the western district of the Mendip Hills.” By the Rev. David Williams, A.M. F.G.S., Rector of the parishes of Bleadon and Kingston-Seamoor, in the County of Somerset. Communicated by Davies Gilbert, Esq. V.P.R.S.

[The Abstract will be given in No. 5. Supplement.]

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1830-1831.

[No. 5.—Suppl.]

June 2.

SIR ASTLEY COOPER, Bart. V.P., in the Chair.

A paper was read, "On the Caves and Fissures in the Western District of the Mendip Hills." By the Rev. David Williams, A.M. F.G.S., Rector of the parishes of Bleadon and Kingston-Seamoor, in the County of Somerset. Communicated by Davies Gilbert, Esq. V.P.R.S.

The first cavern described in this paper is situated at Uphill, at the very western extremity of the Mendip Hills. Its present entrance is about midway in a mural face of transition limestone, about a hundred feet high. The fissure leading into it is nearly vertical, and was discovered by some quarry-men casually intersecting it. Some bones and teeth being found there, the author was induced to pursue the exploration of the fissure; in the course of which he discovered bones of the rhinoceros, hyæna, bear, ox, horse, hog, fox, polecat, rat and mouse, and also of birds. The bones of the animals of the larger species were so gnawed and splintered, and evidently of such ancient fracture, that no doubt could exist of the cave having been a hyæna's den, similar to Kirkdale and Kent's Hole. All the ancient remains were found in the upper regions of the fissure, and were so firmly imbedded in the detritus, as not to be extracted without difficulty with the pick-axe. Further on he found a wet tenacious loam, abounding with an innumerable quantity of bones, belonging exclusively to birds. After working six days he came to a cavern, ten or twelve feet high, extending about forty feet from north to south, and varying from eight to twenty feet from east to west; the floor of which was covered with bones of sheep: and on digging into the mud and sand of which it consisted, the bones of sheep, birds, cuttle-fish, and foxes, were discovered. Some fine stalactites depended from the roof, and partial spots of stalagmite appeared on the floor. In a fissure that branched from the mouth of the main entrance there were found, among the sand, a piece of black Roman pottery, and two coins, one of Didius Julianus, and the other of Julia Mammæa, together with bones of sheep, cuttle-fish, foxes, and birds.

The author considers that there exist evidences of the operation of water at three distinct periods of time:—the first indicated by

the bones of the hyæna, and the other gnawed bones firmly imbedded in the diluvial detritus: the second, when sand was deposited by the sea in the second fissure, that washed in through the vertical chimney, and that inundated the whole valley up to Glas-tonbury: the third irruption of the sea occurring within these fifteen hundred years, and choking up the adit from the level by which the sheep and foxes had entered, floating in the bones of the cuttle-fish, and depositing the thin crust of mud which covered the sand. The coins and pottery he supposes to have been introduced through this entrance from the level.

The author next gives an account of the Hutton caverns, situated on the northern escarpment of the range, commonly called Bleadon Hill. This cavern had been discovered some time ago and noticed by Mr. Catcott in his "Treatise on the Deluge:" but afterwards it became inaccessible by the falling in of the roof and sides. The author, led by some indications of pieces of ancient bones in the rubbish of some old pits, sought for this cavern by sinking a shaft, and succeeded in opening into it. The chambers he reached are probably the western extremity of a very extensive range of caverns, occurring in a region bearing marks of great disturbance, abounding in chasms and fissures, and containing a great number of bones. The principal of those discovered belong to the elephant, tiger, hyæna, wolf, boar, horse, fox, hare, rabbit, rat, mouse, and bird. No trace of the bones of the ox were discovered here, although in the cave at Banwell Hill, about a mile distant, they abound; while, on the other hand, no vestige of the horse is met with.

Among the remarkable specimens found in the Hutton caverns were the milk-teeth and other remains of a calf elephant about two years old, and those of a young tiger just shedding its milk-teeth; and also the molares of a young horse that were casting their coronary surfaces;—the remains of two hyænas of the extinct species; and two or three balls of *album græcum*.

The Banwell caves, lying about a mile to the east of Hutton, are next described. They are the property of the present Bishop of Bath and Wells; and contain remains of the bear, wolf, fox, deer, and ox. Of the bear there are at least two species; one of which appears to be the *Ursus spelæus* of Blumenbach, and must have been an animal of immense size and strength. These remains were, in general, not associated according to the animals they belonged to, but indiscriminately dispersed: thus the head of a bear lay by the femur of an ox, and the jaw of a wolf lay by the antler of a deer. Hence the author infers that these bones, after accumulating for ages, were carried in by a tumultuous rush of waters, and mingled together before their final deposition. He concludes that the several animals whose remains are deposited in the Banwell and Burlington caves belonged to a very different age and period from those found at Hutton and Uphill.

An account is also given of two caves at Burrington Coomb, lying about six miles to the east of Banwell, in one of which, though

similar in appearance to the caves already described, no antediluvian remains of animals have been found. Several human skeletons, and flint knives and celts, were discovered there by Mr. Williams; from which it has been inferred that it had formerly been used as a burying-ground. In the upper caverns, remains of the bear, elk and polecat, were discovered; the two former evidently of the extinct species.

PROCEEDINGS

OF

THE ROYAL SOCIETY.

1830-1831.

No. 6.

June 9, 1831.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The Hon. Frederick de Roos, and Edward Coleman, Esq., were elected Fellows of the Society.

The following Presents were received, and thanks ordered for them:—

Transactions of the Cambridge Philosophical Society. Vol. 3, Part 3; and Vol. 4, Part 1. 4to.—*Presented by the Society.*

Zoological Society.—Report at the Anniversary Meeting, 1831.

————— Notices of Proceedings (March 8 to May 10, 1831). 8vo.—*The Society.*

Yorkshire Philosophical Society.—Annual Report for 1830. 8vo.—*The Society.*

Astronomical Observations made at the Radcliffe Observatory, Oxford; from April 30, 1830, to April 30, 1831. By Professor Rigaud, F.R.S., folio MS.—*The Radcliffe Trustees.*

Astronomical Observations made at the Observatory of Cambridge. By G. B. Airy, M.A. Vol. 3: 1830. 4to.—*Professor Airy.*

A new illustrated Road Book of the Route from London to Naples, containing Twenty-four highly finished Views. Part 1. London to Paris. By W. Brockedon, Esq. 8vo.—*The Author.*

A Volume containing various Documents, and a Lecture, relative to the Prevention of Shipwreck; and an Essay on the Extinction and Prevention of destructive Fires. By Captain G. W. Manby. 8vo.—*The Author.*

Nuovo Desideratum di Chine Vere e di Specie Affini, di V. L. Brera, M.D. 4to.—*The Author.*

The Valley of Gosau in the Salzburgh Alps; drawn from Nature, and on Stone, by Charlotte Murchison. (Two impressions.)—*Mrs. Murchison.*

A Portrait Sketch of Frederick Albert Winsor, Originator of Public Gas Lighting, and Founder of the first established Gas Light Companies in England and in France.—*F. A. Winsor, Esq.*

A paper was read, entitled "Researches in Physical Astronomy." By J. W. Lubbock, Esq., V.P. and Treasurer of the Royal Society.

The author extends, in the present paper, the equations he has already given for determining the planetary inequalities, as far as the terms depending on the squares and products of the eccentricities, to

the terms depending on the cubes of the eccentricities and quantities of that order, which he does by means of a table, similar to the one given in his lunar theory; and applies them particularly to the determination of the great inequality of Jupiter, or at least such part of it as depends on the first power of the disturbing force. That part which depends on the square of the disturbing force may, he thinks, be most easily calculated by the methods given in his lunar theory. He recommends it as particularly convenient to designate the arguments of the planetary disturbances by indices. The bulk of the paper is occupied by the tables, and by examples demonstrating their use.

A paper was read, "On the Theory of the Elliptic Transcendents." By James Ivory, A.M., F.R.S., &c.

Fagnani discovered that the two arcs of the periphery of a given ellipse may be determined in many ways, so that their difference shall be equal to an assignable straight line; and proved that any arc of a lemniscate, like that of a circle, may be multiplied any number of times, or may be subdivided into any number of equal parts, by finite algebraic equations. What he had accomplished with respect to the arcs of the lemniscates, which are expressed by a particular elliptic integral, Euler extended to all transcendents of the same class. Landen showed that the arcs of the hyperbola may be reduced, by a proper transformation, to those of an ellipse. Lagrange furnished us with a general method for changing an elliptic function into another having a different modulus; a process which greatly facilitates the numerical calculation of this class of integrals. Legendre distributed the elliptic functions into distinct classes, and reduced them to a regular theory, developing many of their properties which were before unknown, and introducing many important additions and improvements in the theory. Mr. Abel of Christiana happily conceived the idea of expressing the amplitude of an elliptic function in terms of the function itself, which led to the discovery of many new and useful properties. Mr. Jacobi proved, by a different method, that an elliptic function may be transformed in innumerable ways into another similar function, to which it bears constantly the same proportion. But his demonstrations require long and complicated calculations; and the train of deductions he pursues does not lead naturally to the truths which are proved, nor does it present in a connected view all the conclusions which the theory embraces. The author of the present paper gives a comprehensive view of the theory in its full extent, and deduces all the connected truths from the same principle. He finds that the sines or cosines of the amplitudes, used in the transformations, are analogous to the sines or cosines of two circular arcs, one of which is a multiple of the other; so that the former quantities are changed into the latter when the modulus is supposed to vanish in the algebraic expression. Hence he is enabled to transfer to the elliptic transcendents the same methods of investigation that succeed in the circle: a procedure which renders the demonstrations considerably shorter, and which removes most of the difficulties, in consequence of the close analogy that subsists between the two cases.

A paper was read, entitled, "An Experimental Investigation of the Phenomena of Endosmose and Exosmose." By William Ritchie, Esq., M.A., F.R.S., Professor of Natural Philosophy in the Royal Institution of Great Britain.

M. Porret had, in the year 1816, announced the discovery, that if a vessel containing water be divided into two compartments by a diaphragm of bladder, and placed in the voltaic circuit, the water would rise on the negative side above its level in the positive compartment. M. Dutrochet discovered, that if alcohol be placed in one of the chambers, and water in the other, without employing the voltaic battery, the water will percolate through the bladder, and the fluid will rise in the chamber containing the alcohol: an action to which he gave the names of *Endosmose* and *Exosmose*, according to its direction with regard to the side of the membrane considered; comparing its two sides to those of a Leyden jar in opposite electrical states. This electrical theory has been combated by M. Poisson: but the true explanation of this singular phenomenon does not appear to have been yet given.

The experiments of the author, of which an account is given in this paper, were made with a glass tube, about an inch in diameter, one end being drawn out into a slender tube of the interior diameter of one eighth of an inch, and having a piece of bladder tied over the other end. When this *Endosmometer*, as it has been called, is by means of a small funnel introduced into the narrow end filled with alcohol, and immersed in water, the water penetrates through the bladder, and the spirit rises rapidly in the narrow stem. The author found on trial that this action was apparently not affected by a powerful current of voltaic electricity passed through the bladder, by introducing positive and negative wires on both sides of it. On substituting a strong solution of sulphate of zinc for the alcohol, the same negative result was obtained.

The author considers the action of the animal membrane to be the consequence of its strong attraction for water, an attraction to which it owes its hygrometric properties; while, on the other hand, the membrane has no attraction for alcohol, which has itself a powerful attraction for water. The water, therefore, finds its way easily through the membrane, and uniting with the alcohol, is carried off by it, and diffused through the liquid, making room for the other portions that successively come over. Whalebone and quills have similar hygrometric properties, and may be substituted for membranes with the same effect. All substances readily soluble in water give rise to the phenomena of endosmose, on the same principle as alcohol, such as gum, sugar, and salts. The phenomenon bears a striking resemblance to the rise of the sap in the capillary vessels of plants, both being probably dependent on the same principle; the filamentous texture of the roots performing the function of the membrane, and the contained sap that of the attractive fluid; by the agency of which that external moisture of the earth is imbibed and raised into the interior of the plant.

June 16.

JOHN W. LUBBOCK, Esq., V.P. and Treasurer,
succeeded by
HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

Griffith Davis, Esq. was elected a Fellow of the Society.

The following Presents were received, and thanks ordered for them:—

Trigonometrical Survey of Great Britain and Ireland.—Sheets 41 and 54 (Parts of Carmarthenshire, Worcestershire, and Warwickshire). 5 Maps.—*Presented by the Hon. Board of Ordnance.*

Proceedings of the Geological Society. No. 21. 8vo.—*The Society.*
A Treatise on Algebra. By the Rev. George Peacock, M.A., F.R.S. 8vo.—*The Author.*

On the Health of the Royal Navy, at the End of the 18th and Beginning of the 19th Century: with Practical Illustrations. By Sir Gilbert Blane, Bt. F.R.S. 8vo.—*The Author*

Reflections on the present Crisis of Public Affairs; with an Enquiry into the Causes and Remedies of the existing Clamours, and alledged Grievances of the Country. By Sir Gilbert Blane, Bt. F.R.S. 8vo.—*The Author.*

Catalogue of Oriental Manuscripts purchased at Aleppo, Damascus, Cairo, and Constantinople, by the assistance and recommendation of the late Mr. J. L. Burckhardt. 4to.—*John Lee, LL.D., F.R.S.*

Synopsis Reptilium; or Short Descriptions of the Species of Reptiles. By John E. Gray, Esq. 8vo.—*The Author.*

An engraved Portrait of John Taylor, Esq. F.R.S. Engraved by Turner from the Painting by Sir Thomas Lawrence.—*Mrs. Taylor.*

A Lithographic Portrait of Major-Gen. Hardwicke, F.R.S. From the Painting by Lucas.—*John E. Gray, Esq.*

Mémoire sur la Propagation du Mouvement dans les Milieux Élastiques. Par M. Poisson. 4to.—*Baron Poisson, For. Memb. R.S.*

Mémoire sur le Mouvement de deux Fluides Élastiques superposés. Par M. Poisson. 4to.—*The Author.*

Åminnelse-Tal öfver Kongl. Vetenskaps-Academiens Framlidne Ledamot, Herr Adolf Murray, M.D. Af dess Ledamot Erik Gadelius, M.D. 8vo.—*The Author.*

Tal om Sveriges naturförhållanden och om den inflytelse de äga på dess näringar och slöjder. Af Carl Arosenius. 8vo.—*The Author.*

A paper was read, "On the Tides in the Port of London." By J. W. Lubbock, Esq., V.P. and Treas. R.S.

This paper contains a discussion of observations of the tides made at the London Docks, and registered in various Tables, showing

the time and height of high water, not only at different periods of the moon's age, but also for the different months of the year, for every minute of the moon's parallax, and for every three degrees of her declination. The tables themselves were registered by Mr. Dessiou of the Admiralty: but the arrangement of the tables and the methods employed are due to the author. The tides in the river Thames are extremely regular; and as the rise is considerable, the observations on them are easily made. Those at the London Docks present an uninterrupted series from the opening of the Docks in 1804 to the present time: which is more extensive than any extant, with the exception only of that made at Brest by order of the French Government. Some observations are also given of the tides made during one year at the East India Docks, under the superintendence of Captain Eastfield, and which were undertaken at the suggestion of the author, and made with extreme care.

The author gives an account of the mode by which the several tables were constructed; and enters at length into the various mathematical considerations which the subject involves.

The author was enabled, by the kindness of the Chairman and Directors of the London Dock Company, to present to the Society the books containing the complete series of original observations on the tides referred to in this paper.

A paper was read, "On the Friction of Fluids." By George Rennie, Esq., V.P.R.S.

The object of the author in this paper is to trace the relation subsisting between the different quantities of water discharged by orifices and tubes, and the retardations arising from the friction of the fluid. The results of the experiments hitherto made with a view of ascertaining the effects of the friction attending the mutual motion of solids and fluids, are exceedingly discordant, and therefore undeserving of confidence. Whether, for example, the retardation from friction be proportional to the surfaces, or to the velocities, are points by no means satisfactorily determined.

The experiments of the author were designed to measure the retardations experienced by solids moving in fluids at rest; and of fluids moving over solids. For this purpose, he employed a cylinder of wood, about eleven inches in diameter and two feet in length, traversed by an iron axle, upon the upper part of which a small pulley was fixed. A fine flexible silken cord was wound round the pulley, at one end, and had a weight attached to the other end. A frame was provided, allowing the apparatus to slide up and down; and the cylinder to be immersed at various depths into the river Thames. When the velocities were small, the retardation was found to be nearly as the surface: but with great velocities it appears to have but little relation to the extent of the surface immersed. The resistances of iron discs and wooden globes revolving in water were found to be as the squares of the velocities.

From the experiments made on the quantities of water discharged by orifices of different shapes and sizes from vessels kept constantly

full, the author concludes, that they are in the ratio of the areas of the orifices, independently of their shape; and nearly as the square roots of the heights. In pipes bent at various angles the retardation occasioned by the flexure was not in proportion to their number.

A paper was read, "On the Sources and Nature of the Powers on which the Circulation of the Blood depends." By A. P. W. Philip, M.D. F.R.S. L. & Ed.

In the first part of this paper the author discusses the opinions which ascribe the powers that maintain the circulation in the veins to the elasticity of the heart, the resilience of the lungs, and the dilatation of the thoracic cavity in the act of inspiration. He shows experimentally that the circulation continues unimpaired when all those causes have ceased to operate; and that the very structure of the veins, the coats of which are so pliable as to collapse by their own weight, when empty, renders it impossible that the motion of the blood could be maintained in them by any cause corresponding to a power of suction in the heart.

The latter part of the paper is occupied by an inquiry into the sources and nature of the powers which really support the circulation of the blood. The capillaries, he observes, maintain the motion of their blood long after the heart has ceased to beat; this motion not being immediately affected even by the entire removal of the heart; but being accelerated, retarded, or arrested, according as the action of the capillaries is increased, impaired, or destroyed, by agents of which the operation is wholly confined to the vessels themselves. As the destruction of the heart does not immediately influence the motion of the blood in the capillaries, so the action of this organ, when in full vigour, can produce no motion of the blood in the capillaries, when these vessels are themselves deprived of power. Experiments are related with the view of proving that the arteries and veins, and more particularly the latter, are also capable of carrying on the blood they contain, even in opposition to the force of gravitation, with the greatest ease, and without the aid of any extraneous power. With regard to the nature of the power exerted by the blood-vessels, the author shows that the capillaries are as readily influenced by stimulants and by sedatives, as the heart itself; and that the arteries and veins may also be made to obey the action of stimulants; and further, that the power of the vessels bears the same relation to the nervous system as that of the heart, which is peculiar, and very different from the relation subsisting between that system and the muscles of voluntary motion. From the whole of the facts and experiments stated in this paper, the author deduces the conclusions, that the circulation is maintained by the combined power of the heart and blood-vessels, and that the power of both is a muscular power.

A paper was read, entitled, "A critical and experimental Inquiry into the Relations subsisting between Nerve and Muscle." By

Wm. Charles Henry, M.D., Physician to the Manchester Royal Infirmary. Communicated by Wm. Henry, M.D., F.R.S.

It has long been a subject of controversy among physiologists whether muscular contraction is the immediate consequence of the action of a stimulus on the muscular fibre, or whether it is necessarily dependent on a change taking place in the nerve distributed to the muscle, and excited by the stimulus. This question, the author observes, is one which, from its very nature, is incapable of a direct solution, because the intimate connection of nervous fibres with every part of the muscles renders it impossible to distinguish on which of these classes of textures the impression of the stimulus is primarily made. The continuance of the motions of the heart after the destruction of the brain and spinal cord, and even after the entire removal of the heart from the body, has been adduced as an argument of the independence of the contractile property of the muscular fibre: but this argument the author considers as inconclusive, because the nervous fibres remaining in the heart, and expanded on the interior of its cavities, may still be capable of performing their usual functions, and act as the medium of excitation to the muscular fibres: an hypothesis strongly supported by the analogy of the voluntary muscles, which, though usually excited to action by changes taking place in the central portions of the nervous system, may yet, when removed from this influence, be made to contract by irritations applied to the trunks of the nerves that supply them.

As narcotic poisons act exclusively upon the nervous system, the author conceived that they might afford the means of eliminating the action of the nerves, and thus enable us to discover what share they contribute towards muscular contraction. On applying the empyreumatic oil of tobacco, or the hydrocyanic acid, to the sciatic nerves of a rabbit, he found that the functions of that part of the nerve which was in contact with the poison was destroyed, and that irritations applied to that part no longer excited contractions in the muscles. But when the portion which had been so affected was cut off, and the galvanic wire applied to that extremity of the nerves which remained attached to the muscle, contractions were produced. Similar results were obtained when the poison was applied directly to the brain. When, on the other hand, the poison was applied to mucous surfaces so as rapidly to extinguish life, the muscles throughout the whole body were paralysed and lost all capability of being excited to contraction.

The inefficacy of opium applied to the cardiac nerves in arresting the motions of the heart has often been alleged as a proof that those motions are independent of the nerves. But the author found on trial that a solution of opium injected into the cavities of the heart, or introduced into the intestine, immediately arrested the muscular actions of these organs.

These phenomena appear to the author to accord best with the hypothesis that the immediate antecedent of the contractions of the muscular fibre is a change in the ultimate nervous filament distributed to that fibre.

A paper was read, entitled, "Experiments on the Length of the Seconds' Pendulum; made at the Royal Observatory at Greenwich." By Captain Edward Sabine, of the Royal Regiment of Artillery, F.R.S.

The experiments described in this paper were made with the original convertible pendulum constructed by Capt. Kater, and employed by the author in Portland Place, in the year 1817; except that the tail pieces were removed, and the moveable weight dispensed with: and they were made on the vacuum apparatus established in the south-west angle of the Pendulum-room, the place assigned for it by the Astronomer Royal. Having had reason to suspect that the retardation of the vibrations of the pendulum performed in circular arcs, when the weight was above, was greater than that assigned by the formula commonly employed, the author first investigates the correction necessary to be applied from this cause. He next ascertains the reduction to a vacuum for the small residue of air which the apparatus still contained, or for the small portion which may have introduced itself by leakage. The alteration of rate for each degree of Fahrenheit is then determined to be 0.441, a quantity almost exactly the same as that which was deduced from a former inquiry. The result of the present inquiry is, that the vibrations of Captain Kater's pendulum, which at 57° were found to be 86069.1, are at 62°, 86066.9. At this latter temperature, the length of the seconds pendulum, in vacuo, would be 39.13734 inches. Tabular details of the experiments accompany the paper.

A paper was read, "On recrossed Vision; being the Description of a distinct Tribe of ocular Phenomena, supplementary to a Rationale of the Laws of cerebral Vision, recently published." By John Fearn, Esq. Communicated by Captain John Grover, F.R.S.

The phenomena described in this paper, and which the author designates those of *recrossed vision*, are cases in which objects placed between and very near the eye, such as the two sides of the nose, appear on opposite sides of the sphere of vision: the object on the right side of the nose being seen to the left by the right eye, and that which is on the left of the nose being seen to the right by the left eye. These and other phenomena illustrative of the well-known law by which we estimate the position of objects with relation to the eye to be in a line drawn from its image in the retina through the centre of the eye, are considered by the author as requiring further explanation. Not satisfied with the theory of Berkeley, that the mind is guided by the perceptions received from the sense of touch, in interpreting the signs furnished us by the sight, the author proposes to explain these phenomena by an hypothesis of his own, which he states in the following words. "Over and above the gift of two external or cranial eyes, man has been by his adorable Creator endowed with an internal cerebral organ, which performs the office of a *third eye*, by being the common recipient of impressions propagated either from one, or both of the external eyes; and the mind, in her chamber of percipience, steers with regard to ex-

ternal objects by the same principle on which the mariner steers by his compass. Thus the two cranial eyes are analogous, in principle and situation, to two magnetic compasses placed upon a ship's deck; while the third, or cerebral eye, corresponds to another compass placed in the cabin below; and the mind, situated like the captain-mariner in his cabin, knows, from consulting the cerebral eye, on what point of direction the body is steering; although the mind no more perceives either any external object, nor yet any image in the cranial eye, than the mariner perceives (even in the vulgar sense of the word perceiving) the far-off land, or haven, towards which he is surely making his way."

A paper was read, "On the Thermostat or Heat Governor, a self-acting physical Apparatus for regulating Temperature;" constructed by Andrew Ure, M.D., F.R.S.

The principle of the instrument here described is the unequal expansion of different metals by heat. A bar of zinc, alloyed with four or five per cent. of copper, and one of tin, about an inch in breadth, one quarter of an inch thick, and two feet long, is firmly and closely riveted along its face to the face of a similar bar of steel of about one third in thickness. The product of the rigidity and strength should be nearly the same, so that the texture of each may pretty equally resist the strains of flexure. Twelve such compound bars are united in pairs by a hinge joint at each of their ends; having the zinc or alloy bars fronting one another. At ordinary temperatures these bars will be parallel, and nearly in contact; but when heated, they bend outwards, receding from each other at their middle parts, like two bows tied together at their ends. When a more considerable expansion is wanted, a series of such bars is laid one over the other. The movement thus resulting is applied by the author in various ways to regulate the opening of dampers, letting in either cold air or cold water, or closing the draught of a fireplace, as the case may be. He proposes its employment to regulate the safety valves of steam boilers, as working with more certainty than the common expedients.

A paper was read, "On the Determination of the Thickness of solid Substances, not otherwise measurable, by Magnetic Deviations." By the Rev. William Scoresby, F.R.S. Lond. and Edin. Corresponding Member of the Royal Academy of Sciences of Paris, &c.

In the first part of this paper, the author states the results of a series of experiments undertaken by him with the view of ascertaining whether all bodies are equally and uniformly permeable to the magnetic influence. Out of a great number of substances not ferruginous, but of various qualities, thickness, and solidity, which were subjected to trial, no instance occurred of their offering any perceptible obstruction to the action of a magnet on a compass, when interposed between them. No interruption to this action occurred even when the intervening bodies were iron ores, of which several

were tried, excepting in one or two cases in which the ore was found to be itself magnetic. Hence the author was led to conceive that an accurate estimation of the magnetic influence transmitted through solid substances, might afford an excellent mode of ascertaining the thickness of such substances which might not be otherwise determinable. In order to judge of the degree of accuracy with which this might be accomplished, he instituted various sets of experiments; first placing the magnet in a line pointing to the centre of the compass, and on a level with it, in the east and west magnetic direction; and secondly in positions more or less oblique to this direction. He found reason to conclude from these trials, that the degree of accuracy attainable by this method was such as to render it highly advantageous in mining operations. Thus the thickness of a mass of freestone rock on the Liverpool and Manchester rail-way, three feet two inches in thickness, was determined by this method to within the eighth of an inch of its actual measurement, exhibiting an error of only one 334th part of the whole.

Many experiments were made to determine the effect which the form, dimensions, quality, and number of magnets have on the extent of their directive influence on the compass. It was found that little, if any augmentation of power results from increasing the thickness of the magnet: but that, with magnets of similar form, the directive forces are nearly in the direct ratio of their lengths. The author gives the results of an extensive series of experiments on the combined influence of several magnets, arranged, either in contact or in juxta-position, in a great variety of ways. The contact of dissimilar poles was in all cases productive of an increase, and that of similar poles of a diminution of efficiency.

In the second part of this paper the author enters into an investigation of the law of the magnetic directive power with reference to distance: in which he finds it convenient to estimate all distances in multiples of the length of the magnet employed, or, more correctly, of the interval between its two poles. From the established law of magnetic force,—namely, that it is in the inverse duplicate ratio of the distance,—the author deduces formulæ for estimating the directive power of a magnet on a compass at different distances. The combined action of four magnets, on a compass of Captain Kater's construction, which was five inches in diameter, will afford a tolerably accurate measurement of the thickness of any solid intervening substance, when about forty feet thick; but even at the distance of eighty-two feet the deviation produced by the magnet will be two minutes of a degree, and therefore still very appreciable. But the sensibility of the compass to the magnetic influence might be much further increased, by the application of a small directing magnet, placed in such a situation as to neutralize the greater part of the directive influence of the earth. By this means the author obtained a deviation in the compass of about $5'$, at a distance of 61 feet, which extended through a variety of solid materials including soil, stones, and brick-work.

In the third part of this paper the author treats of the practical

application of the magnetical influence in engineering, in tunneling, and in mining, for determining the thickness of solid masses in different situations where circumstances preclude the possibility of direct measurement. He adduces a variety of instances in which the information thus obtained would prove of the greatest value, in directing the operations in progress, or determining those to be undertaken, and frequently in preventing the occurrence of accidents which the want of such knowledge may occasion. He concludes with a statement and explanation of various practical directions for the employment of the method recommended.

A paper was read, "On a new Register Pyrometer for measuring the Expansion of Solids." Part II. By J. F. Daniell, Esq. F.R.S., Professor of Chemistry in King's College, London.

In this paper, which is a sequel to that published in the *Philosophical Transactions* for 1830, the author prosecutes the series of experiments he had commenced on the dilatation of the metals: pursuing the comparison between the results of the experiments of Dulong and Petit, with those given by his own instrument. He finds a striking accordance between them in the case of copper, as he had already done with respect to iron and platina. He gives the result of some trials which he made with a view to obtain registers of uniform composition, so as to preclude the necessity of determining the rate of expansion in each individual instance. The results of his experiments on the dilatation of the metals are given in tables; the first showing in arcs of the scales the expansions of four metals from 62° to 212° , and thence to 662° of Fahrenheit; and their respective melting points: and the second, exhibiting the expansion of certain alloys to the same points. The experiments on the melting point of cast iron give a mean of 2768° , and present a remarkable coincidence with the corrected temperature deduced from the expansion of a platina bar, plunged into melted cast iron, which was 2786° ; thus affording a conclusive proof of the accuracy of the pyrometer, and of its competency to determine fixed and comparable points of very high temperature. The author accordingly thinks himself warranted in recommending the introduction of the instrument extensively in all arts and manufactures, where it is an object to regulate high temperatures, and where it is calculated to determine many questions of the highest importance both to practical and theoretical science.

Two papers were read; the one entitled, "On the Influence of Screens in arresting the Progress of Magnetic Action:" the other, "On the Power of Masses of Iron to control the attractive Force of a Magnet." By William Snow Harris, Esq. F.R.S.

The object of the first paper is to show that every substance susceptible of magnetism by induction, when interposed as a screen, tends to arrest the action of a magnet upon a third substance: this intercepting power being directly as the mass, and inversely as the susceptibility to induced magnetism. Thus, although a single plate

of iron, about the sixteenth of an inch thick, effectually intercepts the action of a revolving magnet on a disc of copper, the same result is not obtained when the disc acted upon is also of iron, instead of being of copper; unless the mass of iron interposed be very considerable. The screening influence he found to depend on the mass of iron that is interposed, and not on the surface merely. He was led to suspect that a similar effect might be obtained by employing substances not of a ferruginous nature, provided they were interposed in considerable masses, and the result of his trials justified his conjecture. An account is given of several experiments made with large masses of silver, copper, or zinc, of about four inches in thickness, which being interposed between a revolving magnetic plate and a delicately suspended disc of tinned iron, completely intercepted the action of the magnet on the iron.

The author considers this interceptive property to be more or less common to every class of substance; and that in order to render it sensible, it is only necessary to employ the bodies in masses, bearing some direct ratio to their respective magnetic energies. Thus lead, having a weaker magnetic energy than copper, must be employed in a larger mass in order to produce an equal effect; and to render the screening power of ice sensible would require it to be above thirty feet in thickness. If, instead of interposing the screen of iron immediately between the revolving magnet and the suspended disc of copper, the iron be brought very near the under surface of the magnet, a similar neutralizing influence is exerted.

In the second paper, the investigation of this subject is resumed, and the neutralizing power of a mass of iron investigated under different circumstances. From the experiments detailed by the author, he is led to infer that substances highly susceptible of receiving transient magnetism, are the most efficient in their operation as screens; this operation being referrible to their neutralizing power. It is, however, very difficult to render this power sensible in the case of non-ferruginous bodies, unless they be actually placed between the magnet and the substance acted upon, so as to neutralize effectually the actions of those points which are nearest to each other. The attractive force exerted between a magnet and a mass of iron he finds to be always in the direct ratio of this controlling or screening power of the iron, or, in other words, to its neutralizing power in similar circumstances.

The author suggests that a temporary magnetic state may be conceived to be induced in a substance in two ways: either by the immediate action of the magnet upon each individual particle of the given substance, or else by the action of each particle of that substance on the next in succession, producing a propagation of magnetism from the one to the other. It may also, however, take place in both these ways at the same time. But these different modes of action appear to be in some inverse ratio of each other: for when the retentive or absorbing power of the substance is considerable, the power of the magnet becomes soon controlled; because the particles of the substance first acted upon, begin to operate as screens

to the succeeding ones, and the induced magnetism after a certain point, proceeds entirely by communication from particle to particle, until the whole power is expended. When, on the contrary, the retentive power of the given substance is small, little or no screening energy exists between its particles, in which case the magnetic excitement will depend upon the influence of the magnet on each individual particle: hence it is only by the succession or multiplication of effect resulting from a great number of particles, that we at length render the controlling power of such a substance sensible. The diminished action of a magnet on a disc of copper, when intersected by radiating grooves, seems to be owing to this cause, since a portion of the substance, requisite to the full development of the magnetic energy, is removed. In confirmation of this reasoning it was found that the number of oscillations of a delicately suspended bar, made in vacuo, in a given arc, surrounded by a mass of copper formed into rings, did not sensibly differ when, in the one case, that mass was made up of concentric rings, and, in the other, was entirely solid: while, on the contrary, by removing a very thin external lamina from the former, the number of vibrations was sensibly changed.

The concluding part of this paper is occupied by speculations on the nature of magnetic action: the author being disposed to regard a magnet as rather in a passive than an active state, when exhibiting the phenomena of magnetic attraction. This attraction he considers as the result of an impression first made on the magnet by the iron which appears to be attracted by it: because he finds that with different masses of iron of the same quality, the force at the same distance is unequal; being with some pieces very sensible, whilst with others it is altogether inappreciable. He views a magnet as a substance put into a peculiar state or condition, in consequence of which it exhibits certain properties when subjected to external excitation; in a way analogous to the elastic force of a spiral spring, which is not called into action unless that spring is stretched by a weight suspended to it, or by some other extraneous force. In the case of magnetism, the exciting substance is likewise affected in a similar manner with the magnet which it excites; and the analogy of the spiral spring may be further pursued, in order to render the two cases corresponding, by supposing the weight which elongates the first spring to be itself another similar spiral spring, which is also elongated while exerting its force on the first. Under these circumstances the separation of the coils will be greatest at the upper end of the whole combination of springs, at least at the lower part, presenting a contrariety of states at the two extremities, analogous to the opposite polarities of the two ends of a magnet.

A paper was read, "On the Atmosphere of Mars." By Sir James South, F.R.S.

The author refers the origin of the hypothesis of the "Extensive Atmosphere of Mars" to the observations of Cassini and Røener, made at Briare and Paris in the year 1672. By the former it would

seem that a star of the fifth magnitude became invisible with a three-feet telescope when at a distance of six minutes from the planet; whilst by the latter the same star, after having undergone occultation by the planet, could not be perceived with a large telescope till Mars had receded from it a distance equal to two thirds of his own diameter; although with the same instrument stars of similar magnitude might be easily distinguished even when in contact with the moon's limb.

As opposed to these observations, the author advances his own. One, dated Blackman-street, February 19, 1822, in which a star of the ninth magnitude as seen with the five-feet equatorial suffered no diminution of its apparent magnitude, at a distance of 103 seconds from the planet. A second, on the night following, when the star 42 Leonis having been seen within a second of a degree of the planet's limb prior to occultation by the planet, was perceived after emersion, when only one second and one tenth from it; the instruments of observation in this instance were the five-feet equatorial and the thirty-inch Gregorian reflector, the former instrument being used by the author, the latter by Mr. Henry South. The third was made at Campden Hill, on the 17th of March of the present year, with an eight-feet achromatic of six inches aperture; and in this the star 37 Tauri was with a power of 320 seen actually touching the planet's limb.—The star in neither instance suffered more diminution of brightness than might fairly be attributed to the diffused light of the planet.

From these observations, and the apparently contradictory ones of Cassini and of Røener, the author of this paper infers, that the existence of the extensive atmosphere of Mars is a subject highly meriting further investigation.

He then directs attention to the fact that 37 Tauri was of a red colour when in contact with Mars; whilst 42 Leonis was under similar circumstances of a blue colour: and, from inferences dependent upon observation, states, that the apparent anomaly is easily reconcilable, and that an hypothesis is not wanted to account, on the occasion alluded to, either for the red colour of the one star, or the blue colour of the other.

A paper was read "On the Inflexion of Light." By John Barton, Esq. Communicated by Davies Gilbert, Esq. V.P.R.S.

The design of the author in undertaking the experiments of which he gives an account in the present paper, is to carry on the investigation of the phenomena of the inflexion of light from the point at which it was left by Newton. He begins by examining these phenomena in their simplest form, comparing the appearance of the shadow of an opaque body on a screen of white paper at different distances, with the appearance it would exhibit if the rays passed by the edge of the body, without suffering any deviation from a rectilinear course. It is well known that, under these circumstances, the real shadow is broader than the geometrical shadow, indicating a deflexion of the rays from the edge of the

intercepting body. By varying the distances at which the observations are taken, it is found that the rays are not bent at a sharp angle, but pursue a curvilinear course, the concavity of which is towards the shadow, the curve itself resembling an hyperbola. A luminous halo also appears beyond the shadow; the breadth of this halo agreeing accurately, at all distances, with the space which the penumbra should occupy, if the rays were not bent. The author thinks it impossible to reconcile the explanation of these phenomena given by Newton, with his own hypothesis concerning the action of solid bodies on light, as stated in the "Principia:" for, in that hypothesis, the rays passing nearest to the edge of an intercepting body are supposed to be bent towards the edge, as if attracted; whereas the explanation proceeds upon the supposition that they are bent from that body, as if repelled. The actual hyperbolic course of the rays is also inconsistent with that hypothesis, which would assign to them a parabolic path. It also appears that the breadth of the spectrum made by receiving the sun's rays through an aperture one tenth of an inch, or more, in width, is less than if the rays proceeded in straight lines; but if the aperture is very much diminished, the result is reversed, the real spectrum being broader than the geometrical spectrum.

The author conceives, that the whole of the observed phenomena will admit of explanation, by assuming that light consists of material particles, endowed with a power of mutual repulsion, in which case they would obey the laws of elastic fluids; and the course of the rays might admit of comparison with the motions of the particles of air, or other similarly constituted fluids, in flowing past an obstacle opposed to their progress. He shows how this hypothesis furnishes an explanation of the deflexion of the rays, and of the curvature of their path; and why that path resembles an hyperbola. He supports this theory by the analogy of the laws of heat, considered as the properties of a material fluid, with those of light; both exhibiting the phenomena of reflexion, refraction, and polarization. The author is inclined to believe that, besides the deflecting force, the presence of which is already established, there exists also an inflecting force, which bends some of the rays towards the intercepting body; and states a variety of considerations in support of this fact. He explains, on the same principles, the phenomena described by Newton under the appellation of *fits of easy reflexion and easy transmission*, which Dr. Young has explained on the undulatory theory, by the principle of interferences; but which may be considered as analogous to the alternating movements of elastic fluids striking against an opposing body, or entering by a narrow aperture; movements which, in air, give rise to vibrations constituting musical sounds.

The Society then adjourned over the Long Vacation, to meet again on the 17th of November.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1830-1831.

No. 7.

November 17, 1831.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The following Papers were read. The first was entitled, "Researches in Physical Astronomy—'On the Theory of the Moon.'" By J.W. Lubbock, Esq. V.P. and Treasurer of the Royal Society.

This paper is a continuation of the author's former paper on the same subject, in which he gives the developments which are required in the second approximation, or that in which the square of the disturbing force is retained.

The author has not yet attempted to obtain numerical results, but he considers this method of solution equally advantageous with the method hitherto adopted, and that the calculation which would tend to perfect the tables of the moon is a desideratum in physical astronomy.

The author has obtained numerical results in the first approximation; the value of the variation agrees within a few seconds with the result of Newton in the third volume of the *Principia*.

The next paper was entitled, "On the Tides," by the same.

This paper contains tables of the results of observations made at Brest, with regard to the principal inequality of the tides, or that which is independent of the parallax and declinations of the moon and sun, and depends solely on the moon's age, that is, on the time of her passage through the plane of the meridian; from which it appears that the tables of the tides for London are not applicable to Brest, by merely changing the *establishment*, that is, by adding a constant quantity, as has been hitherto supposed; and the same remark applies to any distant parts.

The third paper was entitled, "On the Structure of the Human Placenta and its connection with the Uterus." By Robert Lee, M.D. F.R.S. Physician to the British Lying-in Hospital.

In the year 1780 Mr. John Hunter presented a paper to the Royal Society, in which he laid claim to the discovery of the true structure of the placenta, and of its vascular connections with the uterus. From

the appearances which he observed in a preparation of the gravid uterus, after both the veins and arteries had been injected, and a longitudinal incision made through the anterior parietes of the uterus where the placenta adhered to its internal surface, he was led to conclude that the arteries which are not immediately employed in conveying nourishment to the uterus go on towards the placenta, and proceeding obliquely between it and the uterus, pass through the decidua without ramifying; and that just before entering the placenta, after making two or three spiral turns, they open at once into its spongy substance. The corresponding veins he represents as commencing from the spongy substance of the placenta by wide mouths, and after passing obliquely through the decidua, entering the substance of the uterus and immediately communicating with the proper veins of that organ. Dr. William Hunter's description of the same vessels accords with that of his brother. He regards the placenta as consisting of two distinct parts, namely, an umbilical portion which belongs to the fœtus, and a uterine portion, which belongs to the mother, each having its peculiar system of arteries and veins; and he supposes that while, in the fœtal portion, the arteries and veins form continuous canals, these two sets of vessels communicate, in the uterine portion, by the intervention of cells, into which the arteries terminate, and from which the veins begin.

The subject was afterwards investigated by Noortwyck, Rœderer, and Haller, but without any satisfactory result; and the doctrines laid down by the Hunters were generally acquiesced in by subsequent anatomists.

The author of the present paper having had opportunities of examining six gravid uteri, and many placentæ expelled in natural labour, finds reason to conclude that no cellular structure, such as that described by Dr. Hunter, exists in the human placenta, and that there is no connection between this organ and the uterus by great arteries and veins. He thinks himself warranted in concluding that the placenta does not consist of two portions, maternal and fœtal, but that the whole of the blood sent to the uterus by the spermatic and hypogastric arteries, except the small portion supplied to its parietes and to the membrana decidua by the inner membrane of the uterus, flows into the uterine veins or sinuses; and after circulating through them, is returned into the general circulation of the mother by the spermatic and hypogastric veins, without entering the substance of the placenta. Such have been the results of the author's own examinations of the structure of the gravid uterus, both when injected and uninjected; and also of an examination of the preparations of that organ, contained in the Hunterian Museum at Glasgow, made at his request by Dr. Nimmo. These views are also corroborated by the careful examination by the author of a preparation of the uterus with the placenta adhering to its inner surface, in the Museum of the Royal College of Surgeons of London, which is supposed to have been put up by Mr. Hunter himself nearly fifty years ago. The cellular structure of the placenta has been too hastily inferred from the masses of wax found interspersed

in its substance, after the vessels have been injected ; but this appearance the author ascribes wholly to extravasation in consequence of rupture of the vessels.

November 24, 1831.

JOHN WILLIAM LUBBOCK, Esq. V.P. and Treasurer,
in the Chair.

A paper was read, entitled, "Facts adduced in refutation of the assertion that the Female Ornithorhynchus Paradoxus has Mammæ." By Sir Everard Home, Bart. F.R.S.

The author, after a minute examination, in which he was assisted by Mr. Hartshorn and Mr. Bauer, of three specimens of female ornithorhynchi sent to him by Governor Darling, could not discover mammæ, although these parts are represented as existing by Professor Meckel.

A paper was next read, entitled, "On an Inequality of long Period in the Motions of the Earth and Venus." By George Biddell Airy, A.M. Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge.

The author had pointed out, in a paper published in the Philosophical Transactions for 1828, on the corrections of the elements of Delambre's Solar Tables, that the comparison of the corrections of the epochs of the sun and the sun's perigee, given by the late observations, with the corrections given by the observations of the last century, appears to indicate the existence of some inequality not included in the arguments of those tables. As it was necessary, therefore, to seek for some inequality of long period, he commenced an examination of the mean motions of the planets, with the view of discovering one whose ratio to the mean motion of the earth could be expressed very nearly by a proportion of which the terms are small. The appearances of Venus are found to recur in very nearly the same order every eight years ; some multiple, therefore, of the periodic time of Venus is nearly equal to eight years. It is easily seen that this multiple must be thirteen ; and consequently eight times the mean motion of Venus is nearly equal to thirteen times the mean motion of the earth. The difference is about one 240th of the mean annual motion of the earth ; and it implies the existence of an inequality of which the period is about 240 years. No term has yet been calculated whose period is so long with respect to the periodic time of the planets disturbed. The value of the principal term, calculated from the theory, was given by the author in a postscript to the paper above referred to. In the present memoir he gives an account of the method of calculation, and includes also other terms which are necessarily connected with the principal inequality. The first part treats of the perturbation of the earth's longitude and radius vector ; the second of the perturbation of the earth in latitude ; and the third of the perturbations of Venus depending upon the same arguments.

The computations of the quantities themselves being effected by means of algebraical equations of great complexity, and of numerical calculations of considerable length, which afford in themselves no ready means of verifying their accuracy, the author has been under the necessity of examining closely every line of figures before he proceeded to another. Upon the whole he is certain that there is no error of importance in the numbers he obtained; and that the only probable source of error is the inevitable rejection of figures beyond a certain place of decimals.

In concluding this investigation, the most laborious, probably, that has yet been made in the planetary theory, he remarks that the term in question is a striking instance of the importance to which terms, apparently the most insignificant, may sometimes rise. As an illustration of the magnitude of the errors which might under other circumstances have arisen from the neglect of this term, he further observes, that if the perihelion of Venus and the earth had opposite longitudes, and if the line of nodes coincided with the major axis, the eccentricities and inclination having the same values as at present, the coefficient of the inequality in the epoch would be $8''.9$, and all the other terms would be important. A very small increase of the eccentricities and inclination would double or treble these inequalities.

Anniversary Meeting, Nov. 30.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The President delivered the following Address:—

Gentlemen,

The period, provided by our Statutes, has again come round, when your Officers and Council must be reconstituted by your authority; and I feel myself called upon, in conformity with the custom which has been sanctioned by my predecessors, to address you upon such subjects connected with the Royal Society and its administration, as the events of the last year may have rendered proper to be noticed by me. But before I touch upon other topics, I feel anxious to say a few words upon my own position in the Society, and my views respecting it.

The Chair of the Royal Society has been filled by a rare succession of illustrious men, and I feel proud that I have been judged worthy, upon any grounds, to occupy a situation which has become dignified by its association with the names of those who have conferred so much honour upon our country. It is indeed true that I can enter into no competition with such predecessors, as respects scientific knowledge, which my early education, my public occupations, and even the duties of my rank, have prevented me from cul-

tivating and attaining to that extent I could have wished: but I should do no honour to your kindness, which has placed me in this high and dignified station, if I should profess that I considered myself wholly inadequate to the efficient discharge of many at least of its public duties, or that I felt my occupation of this Chair was likely to prove injurious either to the credit of the Society, or to the advancement of science. If such, indeed, Gentlemen, were my own persuasion, I would not continue to fill this honourable post for another hour.

The ostensible duties, in fact, of your President, are chiefly ministerial: he is your organ to ask and to receive your decisions upon the various questions which are submitted to you; and he is your public voice to announce them. Though he presides at the meetings of your Council, he possesses but one voice among many; incurring an equal responsibility in common with every one of its members. He is your official representative in the administration of the affairs of the British Museum: he presides in your name, by virtue of your election of him, at the Board of Visitors of the Royal Observatory, as appointed by His Majesty's Warrant: he is your medium of communication with public bodies, and with the members of the Government upon the various subjects important to the interests of science, which are either submitted to your consideration, or which are recommended by you, through your Council, for the consideration of others. For many of those functions I feel myself to be somewhat prepared by my habits of life, as well as by my public occupations: and for some of them more especially, if I may be permitted to say so, by that very rank in which Providence has placed me as a member of the Royal Family of this country; for though it would be most repugnant to my principles and my wishes that the weight of my station should in any way influence the success of an application which it was either improper to ask or inexpedient to grant, I should feel it to be equally due to the dignity of this Society and to my own, that the expression of your opinions and of your wishes should experience both the respect and the prompt attention to which it is so justly entitled.

But while I should consider it my duty to exert the just authority of an English Prince in the assertion of your rights, and in the promotion of the success of those objects which you may intrust to my advocacy without these walls, yet within them I trust that I never have made, and that I never shall make use of it, either for the promotion of party purposes, or for the suppression of the candid, free and unbiassed expression of your opinions. In this Chair I appear as the Official Head of a Society comprising a great majority of the most distinguished men in science and in literature within the Three Kingdoms, and in this character alone I wish to be recognised; and it is my most anxious desire to witness around me the free expression and interchange of opinions, subject to no restraints but such as are requisite for the regularity and well government of every numerous and mixed society.

I do not think it necessary, Gentlemen, to apologize to you for thus enlarging upon topics, which, though personal in some respect to myself, cannot be altogether destitute of interest to you; inasmuch as it undoubtedly concerns you to understand distinctly the principles by which I have regulated my conduct hitherto whilst filling this Chair, and to which I shall continue to adhere in case I should be honoured by being re-elected to it. And I am the more anxious that they should be generally known, in consequence of some circumstances which attended my election last year. If any angry or uneasy feelings were called forth upon that occasion, I can assure you that I do not, nor ever did, partake in them; and it would be a source of the most heartfelt pride to me if I could witness their entire extinction in a cordial cooperation amongst all our members to promote the advancement of science and the common honour of our country; to fulfil, in short, the solemn obligation imposed upon us individually and collectively by our charter, to promote the good of the Royal Society, established for the advancement of natural knowledge, and to pursue the ends for which it was originally founded.

Having ventured to say thus much upon a subject of some delicacy, though in no respect painful to myself, I trust that I may be permitted to add a few words more upon another topic which is nearly connected with it, and which is to express my respect for the accomplished philosopher to whom I had the honour, I will not say misfortune, to find myself opposed last year. His name has been familiar to me from my earliest years, for it is that of one whom my Royal Father delighted to patronize, and which is inscribed in imperishable characters upon the great monuments of the universe, the knowledge of which he contributed so greatly to extend. I knew that venerable man when full of years and of honour, and I can well conceive the feelings of placid triumph and pride with which he must have contemplated the rising promise of his son. What the maturer fruits of that early promise have been, it is not necessary for me to state when addressing the members of this Society: it is sufficient to say, that there is no one among the most illustrious men of England whom the concurrent voice of his countrymen would have pointed out as more worthy of the distinguished and peculiar mark of royal favour and approbation which he has so recently received than Sir John Herschel. Towards such a man I can entertain no feelings but those of admiration, respect and goodwill, and which I trust, if fed by a more intimate acquaintance, will ultimately lead to those of sincere friendship.

The labours of your Council during the past year have been more than commonly important, and have been directed to objects which deeply concern the welfare, good government and general utility of our establishment. For the particulars of those labours I must refer you to the Report which has been so ably drawn up by one of your Secretaries, Dr. Roget, and which will be read to you by him at the conclusion of this Address. I trust, however, that in one particular

I may be excused if I trespass upon the province of that Report; if with the natural partiality of an affectionate brother and a loyal subject, I venture to record the gracious expressions of His Majesty when he inscribed his Royal Name in our Charter-book as the Patron of the Royal Society, in the presence of the Council. His Majesty then declared his gracious intention of continuing the same protection to this Society which had been extended to it by his royal predecessors; that His Majesty had learnt from the professional pursuits of his early life to estimate the immense benefits which science had conferred upon this country in particular, and upon the world in general, by perfecting the art of navigation; that it had produced similar effects upon all the arts of life, however apparently remote from the source from which they flowed; that the progress of civilization amongst nations was generally coextensive with the improvements in science and the extent of its practical application; and that His Majesty should feel it to be his duty, as the Sovereign of these Kingdoms, to aid by his encouragement the exertions of the Royal Society to fulfil the great objects of its foundation. His Majesty concluded by recommending us in strong terms to cultivate friendly relations with the great scientific establishments of other countries, with a view to the free and liberal interchange of knowledge and discoveries. And here allow me, Gentlemen, to pause for a moment, with a view to remark that our Gracious Sovereign, in giving us this wholesome admonition relative to foreign scientific bodies, meant in a most delicate and dignified way, silently to convey to us his royal and paternal pleasure and advice as to the harmony and friendly intercourse which he wished us to maintain with all our national institutions, and more particularly amongst ourselves. Such sentiments, Gentlemen, are worthy of a King of England: and permit me further to observe, that it affords me additional pride and satisfaction that circumstances should have combined together so fortunately as to have made me the organ of such gracious communications between our Royal Patron and the Royal Society.

The Council, upon the same occasion, had the honour of presenting, in the name of the Society, a dutiful and loyal Address to Her Majesty the Queen, who most condescendingly received them, and most graciously declared her intention of extending her support and protection to the Royal Society.

The list of Fellows whom the Society has lost during the last year is more extensive than usual, and the time will not allow me more than to take a brief and passing notice of some of them, whose labours have brought them into a more immediate connection with this Society and the great objects which it proposes to pursue.

Mr. Abernethy was one of those pupils of John Hunter who appears the most completely to have caught the bold and philosophical spirit of investigation of his great master. He was the author of various works and memoirs upon physiological and anatomical or surgical subjects, including three papers, which have appeared in our Transactions. Few persons have contributed more abundantly

to the establishment of the true principles of surgical or medical practice in those cases which require that minute criticism of the symptoms of disease, upon the proper knowledge and study of which the perfection of medical art must mainly depend. As a lecturer he was not less distinguished than as an author; and he appears to have possessed the art of fixing strongly the attention of his hearers, not less by the just authority of his opinions, than by his ready command of apt and forcible illustrations. He enjoyed during many years of his life a more than ordinary share of public favour in the practice of his profession; and though not a little remarkable for the eccentricities of his manners and an affected roughness in his intercourse with his ordinary patients, he was generally kind and courteous in those cases which required the full exercise of his skill and knowledge, and also liberal in the extreme when the infliction of poverty and privation was superadded to those of disease.

Captain Henry Foster was a member of the profession which, under all circumstances, is so justly celebrated for activity and enterprise, and which, when wanting the stimulus of war, has on many occasions lately distinguished itself by the zealous and successful cultivation of those studies and the practice of those observations which are so essentially connected with the improvement of navigation. He accompanied Captain Basil Hall, in the *Conway*, in his well-known voyage to South America, and assisted him materially in his pendulum and other observations. He afterwards joined Captain Parry in the second of his celebrated voyages; and at Port Bowen and other stations within the Arctic Circle, he made, with the assistance of Captain Parry and others, a most valuable and extensive series of observations upon the diurnal variation, diurnal intensity and dip of the magnetic needle, and upon other subjects connected with terrestrial magnetism and astronomical refractions, which formed an entire fourth part of our *Transactions* for 1826, and was printed at the especial expense of the Board of Longitude. For these papers he received the Copley Medal; and the Lords of the Admiralty acknowledged their sense of the honour which was thus conferred upon the profession to which he belonged, by immediately raising him to the rank of Commander, and by appointing him to the command of the *Chanticleer* upon a voyage of discovery and observation in the South Seas. It was during the latter part of this voyage that he perished by an unfortunate accident; but I am happy to say that the public is not likely to lose altogether the benefit of his labours, and that he has left behind him an immense mass of observations of various kinds, which the Lords of the Admiralty have confided partly to this Society, and partly to the Astronomical Society, with a view to their publication in such a form as may best serve the interests of science, and may most tend to establish the character and fame of their lamented author.

The Reverend Fearon Fallows was a distinguished cotemporary of Sir John Herschel at Cambridge, and throughout his life an ardent cultivator of astronomical science. In the year 1821 he was

appointed Astronomer Royal at the Cape of Good Hope, to which place he immediately proceeded, though provided only with a small transit and an altitude and azimuth instrument, a clock, and a few other absolutely necessary appendages of an observatory. In the course of the two following years he completed a catalogue of 273 southern stars, which was published in our Transactions for 1824. The delays which subsequently took place in the building of the observatory, which was not completed before 1828, and the want of those capital instruments which were required to put it into complete operation, although they did not interrupt or check either the industry of his research or the accuracy of his observations, yet by making them necessarily imperfect, deprived them of a very considerable part of their value.

When the mural circle at last arrived, and when he at length imagined himself in possession of the means of effecting the great object of his ambition, by making the catalogues of the stars of the southern hemisphere rival, in accuracy and completeness, those of the northern, he found new difficulties meeting him in the derangements occasioned in so large an instrument, by embarking, disembarking, and fixing it, thus producing errors which were nearly irremediable in the absence of the original maker, or of any superior artist. In the midst of these harassing discouragements he was attacked by severe illness, and at the same time deprived of his assistant by a similar cause, yet even under these afflictions he continued true to his duty; and in a letter to one of his friends a short time before his death, he describes himself as being carried daily in a blanket by his servants from his sick room to the observatory for the purpose of winding up his clocks and chronometers. His disease at last assumed the form of an incurable dropsy, and he died a short time before his intended embarkation for England, whither at last he had reluctantly consented to return, when his recovery at the Cape was pronounced to be hopeless.

In the course of the year 1829 he made, in conjunction with Captain Ronald and Mr. Johnstone, a very complete series of pendulum observations, which were published in our Transactions for the year 1830: and the Lords of the Admiralty are in possession of a very extensive series of astronomical observations made during the last seven years of his life, which it is to be hoped that, before long, they will cause to be given to the public.

Lieutenant Colonel Macdonald, son of the celebrated Flora Macdonald, besides many professional and other works, was also the author of two papers in our Transactions for the years 1796 and 1798, containing observations upon the diurnal variation and dip of the magnetic needle made at Fort Marlborough in Sumatra, accompanied likewise by some observations upon their causes.

Mr. Thomas Greator, the well-known musician, was the author of a paper on the measurement of the heights of mountains. He was a person of great modesty and simplicity of character, and possessed a knowledge of some branches of mathematics and of natural

philosophy which is rarely met with in the members of his profession.

Sir Thomas Frankland, as long ago as the year 1795, was the author of a short paper in our Transactions on the welding of cast steel and iron.

Mr. Wm. Strutt of Derby was the author of those great improvements in the construction of stoves, and in the economical generation and distribution of heat, which have of late years been so extensively and so usefully introduced in the warming and ventilation of hospitals and public buildings. He possessed a very great knowledge of practical mechanics, and employed himself through the whole course of a very active life in the furtherance of objects of public utility.

Dr. Parkinson, Archdeacon of Leicester, gained the highest honours at Cambridge, and was the author of a treatise on mechanics. In his early life he was employed, in conjunction with Israel Lyons and others, in the formation of the tables requisite to be used with the Nautical Almanac.

Dr. Sims was a very zealous cultivator of botanical science, and continued for many years the publication of Curtis's Botanical Magazine.

Dr. Ferris, besides other professional publications, was the author of a work entitled "A General View of the establishment of Physic as a Science in England."

The Rev. William Holwell Carr was a gentleman of refined and cultivated taste, and a liberal patron of the fine arts; he has established no slight claim upon the gratitude of his country by the bequest of his collection of exquisite pictures to the British Museum, whose Council have thought it most advisable, for their better preservation and security, as well as for the furtherance of that gentleman's views in making such a magnificent present to the nation, to deposit them in the British Gallery.

The Earl of Darnley was a liberal patron of the Fine Arts, and a zealous friend of all useful public institutions: and he gave a most convincing proof of the interest which he felt in the promotion of natural knowledge, by the formation and maintenance of a noble collection of rare and curious plants and animals.

Mr. Thomas Hope, the justly celebrated author of *Anastasis*, and Dr. Magee, Archbishop of Dublin, author of the great work upon the Atonement, are names not likely to be soon forgotten in the literary history of this country; but they require no further notice from me, as their labours are altogether foreign to the pursuits of this Society.

The only Foreign Member whose death we have to record is the celebrated Sömmerring, who died lately at Frankfort, his native city, full of years and honour. His numerous and most splendid anatomical works, particularly those on the different organs of sense, have long placed him at the head of the anatomists of Germany, and probably of Europe.

I cannot conclude this Address, Gentlemen, without again requesting you to accept my assurances of the sense which I entertain of the high honour of presiding over this Society, and of my determination to promote its interests to the utmost of my power and ability, in case it should be your pleasure to confide them again to my keeping, by electing me a second time to fill this chair.

Report of the Council to the Anniversary Meeting on St. Andrew's Day, 1831.

The Council, to whom the Society has confided the management of its affairs during the past year, in giving an account of the manner in which they have endeavoured to discharge that trust, have in the first place to congratulate the Society upon the honour which has been conferred upon them by His present Majesty's having been graciously pleased to become the Patron of the Society, and by his having expressed a warm interest in its prosperity.

They wish, in the next place, to call the attention of the Society to the alterations they have made in the Statutes. It has for some time past appeared desirable that the Statutes should undergo a thorough revision with a view to their improvement and adaptation to the present state of the Society. The Council, anxious to accomplish this important object in the most effective manner with respect to the permanent interests of the Society, solicited the assistance of such of the Fellows as seemed to be most able, as well as willing, to give them the benefit of their valuable advice and co-operation in the performance of this difficult task. Three members of their own body having, on this occasion, intimated their inability to attend, from the pressure of other avocations, and their wish, in consequence, to retire from the Council, the Society was called upon to supply the vacancies occasioned by these resignations. The number of the Council being completed by these new elections, twenty-one other Fellows (a number equal to their own) were selected from the Society, for the purpose of composing with the Council a Committee of forty-two members for preparing the requisite emendations in the Statutes, and also for inquiring whether it might be advisable to propose any alterations in the existing Charter of the Society.

This Committee held several meetings for the discussion of these subjects. It was found upon investigation, that several improvements which were suggested could not be effected consistently with the powers granted by the present Charter: and it was finally agreed that the advantages to be expected from those changes would be more than compensated by the difficulties and expenses that would attend the procuring of a new Charter. The Committee, therefore, proceeded to direct their attention to the effecting of such emendations of the Statutes as were compatible with the powers granted by the Charter, and which appeared to afford ample means for the introduction of much improvement. Many of the Statutes which, in the course of time, had become no longer con-

formable to the practice, or adapted to the existing circumstances of the Society, were rescinded; many which required an alteration in their form were remodelled; the language in which the whole was expressed was rendered more uniform, consistent and precise; and several new regulations were introduced, calculated, in the opinion of the Committee, to promote the objects and the welfare of the Society. The result of the labours of the Committee has been the amended edition of the Statutes in the form in which they have since been printed, after having been adopted by the Council, according to the forms prescribed in the Charter, and in the former Statutes of the Society. The principal alterations that have been made in the Statutes are the following:

1. The number of Fellows whose signatures are required as proposing and recommending a candidate for election into the Society is now extended to six instead of three.
2. The times of election are now limited to the first ordinary meetings of the Society in December, February, April and June.
3. Such persons as shall in future be elected Fellows will be allowed to pay annual contributions of four pounds, as long as they shall continue to be Fellows of the Society; but no bonds, as heretofore, shall be required for enforcing these payments.
4. Lists of persons whom the Council recommend to the Society for election as Council and Officers for the ensuing year are to be prepared previous to the anniversary meeting.
5. The process of balloting for the Council and Officers at the anniversary meeting has been simplified by the employment of a single balloting list for that purpose.
6. An abstract of the Society's accounts in each year is to be prepared by the Treasurer, and printed for the use of the Fellows.
7. The duties of the Assistant Secretary and of the Librarian are now united in one person, and the office of Housekeeper is abolished.
8. Provision has been made for calling special general meetings of the Society whenever they may appear to be necessary.
9. A great extension has been given to the time during which the Library shall be accessible to the Fellows. It is now ordered to be open every day, Sundays excepted, from eleven o'clock in the morning till four in the afternoon, excepting on Good Friday, and during Easter, Whitsun and Christmas weeks.
10. Provision has been made for an annual inspection of the Library at a stated period.

The new Statutes are now printed for the use of the Fellows, and may be had on application to the Assistant Secretary.

Since these Statutes have been framed, the Council have besides adopted several specific regulations calculated to facilitate the borrowing of books out of the Library, and for ensuring their regular return at the proper period. They have also framed regulations respecting the loan of instruments belonging to the Society, with a view to the accommodation of Fellows wishing to borrow them, and consistently with their preservation in good condition.

Pursuant to the agreement entered into with the Trustees of the British Museum respecting the exchange of the Arundel manuscripts for books suited to the objects of the Society, the sum of £956 Os. 3*d.* was in July last received from the Trustees of the Museum, with the condition annexed, that the money was to be expended exclusively in the purchase of books, and that a list of the books so purchased should be sent to the Trustees. Nearly the whole of this sum has since been applied in the manner stipulated for, and the Library of the Royal Society has in consequence been enriched by a very large addition of works on scientific subjects, which had long been wanting for the supply of its deficiencies in those branches of knowledge, the promotion of which is more particularly the object of the Royal Society.

A communication has lately been received from the Trustees of the British Museum, stating that they expect to realize at least the greater part of the remaining sum due to the Royal Society, on account of the Arundel MSS. by the sale of duplicate books, in the course of the ensuing spring; and that the money so realized will be paid over without delay into the hands of the Treasurer of the Royal Society.

The Council have in the course of the last summer ordered a thorough inspection of the Library, and the accurate completion of its Catalogue, a task for the proper execution of which considerable time and labour have been required, and which is now nearly completed. With the kind assistance of Mr. Dollond, a list has also been made of the philosophical instruments belonging to the Society, and ordered to be printed for the use of the Fellows.

The increase of the Library and the probability of its future extension have rendered it extremely necessary that a more enlarged space should be obtained than that afforded by the apartments at present occupied by the Society. On this account the Council have reason to congratulate the Society on the acquisition they have lately made, by the favour of the Lords Commissioners of His Majesty's Treasury, on the application of His Royal Highness the President, of the rooms lately occupied as the Privy Seal Office.

On a representation made to the Council of the advantages to be expected from the application of the optical principle developed by Mr. Barlow, to the construction of a telescope of large dimensions, the Council appointed a Committee of inquiry into this subject; and having received from them a report favourable to the success of the measure, have given orders to Mr. Dollond to execute a telescope of that description under the superintendence of Mr. Barlow.

The Council have also to announce that they have placed the papers containing the magnetical observations made by the late lamented Capt. Foster in his recent voyage of discovery (and which have been transmitted to the Royal Society by the Lords Commissioners of the Admiralty), in the hands of Mr. Christie, who has obligingly offered to examine them, and has undertaken to condense them with a view to publication by the Society.

The Council being desirous of obtaining authentic documents respecting the tides, applied to the Admiralty for accounts of the rise and fall of the sea, and the exact periods of high and low water at the different sea-ports. Orders have in consequence been given to the proper officers of the Dock-yards at Woolwich, Sheerness, Portsmouth, and Plymouth, to make these observations, and returns have already been received from those places. The Chairman and Directors of the London Dock Company have presented to the Society the books containing a complete series of original observations on the tides, referred to in a paper read to the Society on that subject by Mr. Lubbock; for which favour the Council have returned suitable acknowledgements.

Considerable uncertainty having prevailed with regard to many points relating to the powers entrusted to the Society of conferring certain honorary rewards, and also as to the principles which should guide them in making the several awards of those honours, the Council appointed a Committee for considering the whole of this subject. The Committee, in the execution of this task, have made a diligent search for all the documents relating to these subjects, including the extracts from wills and other authorities, and the resolutions which have from time to time been made by the Council relating to the medals; and have directed that separate lists should be made out of all the persons who have received the honorary rewards bestowed by the Society, specifying the respective dates and subjects for which they were awarded. Their exertions have been ably and diligently seconded by the Assistant Secretary; and the Council have directed that the account which Mr. Hudson has drawn up shall be printed for the use of the Fellows.

The Council, on the recommendation of the Committee, have adopted the following regulations as to the mode of making the several awards entrusted to them.

1. The Copley Medal shall be awarded to the living author of such philosophical research, either published or communicated to the Society, as may appear to the Council to be deserving of that honour. The particular object or subject of research, on account of which the medal is awarded, shall be specified in making the award. No limitation shall exist either as to the period of time within which that research was made, or to the particular country to which its author may belong. It shall not be awarded to any person who is a member of the Council at the time when the award is made. The medal may, as was formerly done, be given more than once to the same person, if the Council deem it expedient so to mark their high sense of the merit of the author. The medal shall, as far as circumstances permit, be awarded annually.

2. No change is made in the mode of awarding the Royal medals, formerly resolved upon by the Council.

3. At the first meeting of the Committee of papers held in each year, some one paper then in the hands of the Secretaries, and intended to be read to the Society, shall be selected as the Bakerian Lecture for that year.

Inconvenience having arisen from the collection which the Porter has hitherto been in the habit of making from the Fellows of gratuities for the delivery of the Lists of the Society, the Council have now ordered that from the day of the next anniversary, he shall receive, in lieu of such gratuities, and of his former salary, a salary at the rate of £60 per annum.

The Copley Medal has been adjudged to Professor Airy of Cambridge, for his papers on the construction of the Achromatic Eye-pieces of Telescopes, and on the Achromatism of Microscopes; on the Spherical Aberration of Eye-pieces, and for his other papers on optical subjects in the Cambridge Philosophical Transactions.

The rules for the practical construction of eye-pieces, which were chiefly formed by the elder Dollonds, were probably deduced by repeated trials, conducted with the usual skill and sagacity of those great opticians, rather than by any very accurate reference to their mathematical theory: in whatever manner, however, they were discovered, they have continued to be adopted by opticians with very little alteration since that time.

The correction of the spherical and chromatic aberration of eye-pieces is at least as important in practice as those of object-glasses; and whilst the theory of the latter has been more than once subjected to a complete analysis, that of the former has been almost altogether neglected. The elaborate and complicated formulæ of Euler are altogether useless for the present constructions; and the more practical investigations of Boscovich, though opening the way to more accurate results, have failed to satisfy the required conditions. Professor Airy, by a more accurate analysis of the theory of oblique pencils of rays, and by connecting his investigations more strictly with the practical conditions of the problem to be solved, has been enabled not merely to satisfy the common constructions and the rules for effecting them, but likewise to point out other constructions with their corresponding rules; and though such constructions have been found, upon trial, to be at least not superior to those which are already in use, it must always be considered as an important step in the advancement of science, that theory should be at least coextensive with practice, and should become a leader and a guide to the latter, instead of a follower in its train. But though the Council have selected the papers on the theory of the correction of the chromatic and spherical aberration of eye-pieces, as forming the principal ground of their decision, yet they are anxious to combine with them other papers in the same Transactions, as deserving of particular commendation, and as showing the profound acquaintance of their author with every branch of optical science. Amongst these may be mentioned the paper on the Double Refraction of Quartz, which is of very recent publication, inasmuch as it affords one of the most striking *à posteriori* proofs which have hitherto been discovered of the truth of the undulatory theory of light; a most difficult mathematical investigation, essentially founded upon that theory, leads him to expect the appearance of phenomena of great beauty and intricacy, as the result of certain experi-

ments which are found upon examination to be almost mathematically exact. It is by such tests, and many others reproducible, that the truth of the theory, which was established and developed by the genius of Young and of Fresnel, becomes established upon evidence scarcely inferior to that of universal gravitation.

The Society next proceeded to the Election of the Council and Officers for the ensuing year, when the following was declared to be the list:—

President.

His Royal Highness the Duke of Sussex, K.G.

Treasurer.

John William Lubbock, Esq. M.A.

Secretaries.

Peter Mark Roget, M.D. John George Children, Esq.

Foreign Secretary.

Charles Konig, Esq.

Other Members of the Council.

Peter Barlow, Esq.	William George Maton, M.D.
John Bostock, M.D.	Roderick Impey Murchison, Esq.
Rev. William Buckland, D.D.	Rev. George Peacock, M.A.
Samuel Hunter Christie, Esq. M.A.	George Rennie, Esq.
Rev. Henry Coddington, M.A.	Captain William Henry Smyth,
Charles Daubeny, M.D.	R.N.
George Dollond, Esq.	Nicholas Aylward Vigors, Esq.
Davies Gilbert, Esq. M.A.	M.A.
Joseph Henry Green, Esq.	Rev. William Whewell, M.A.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1831-1832.

No. 8.

December 8; 1831.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

Thomas Maclear, Esq., Philip Hardwick, Esq., the Right Hon. Lord Oxmantown, and Henry Robinson Palmer, Esq., were elected Fellows of the Society.

The reading of a paper, entitled "Experimental Researches in Electricity," by Michael Faraday, Esq. F.R.S. was commenced.

December 15, 1831.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer,
in the Chair.

The reading of Mr. Faraday's paper, entitled "Experimental Researches in Electricity," was concluded.

This paper is divided into four parts : the first being on the Induction of Electric Currents ; the second, on the Evolution of Electricity from Magnetism ; the third, on a new Electrical Condition of Matter ; and the fourth, on Arago's Magnetic Phenomena.

The author defines *electrical induction* to be the power which electrical currents possess of *inducing* any particular state upon matter in their immediate neighbourhood. A great length of copper wire, 1-20th of an inch in diameter, was wound round a cylinder of wood so as to compose two helices, the coils of which were intermixed, but prevented from touching each other by interposed threads of twine and calico. One helix was connected with a voltaic battery, and the other with a galvanometer. No effect was perceived on the latter, with a battery of 10 plates : a slight effect only with one of 100 plates ; and a distinct deflection of the needle of the galvanometer occurred when the contact was made with a battery of 120 plates. While the contact was preserved, the needle returned to its natural position, and was unaffected by the electric current passing through the wire connected with the battery ; but on breaking the connexion, the needle of the galvanometer was again deflected, but in a direction contrary to that of its former deflection. Hence it is inferred that the electric current sent by the battery through one

wire; induced a similar current through the other wire, but only at the moment the contact was made; and a current in the contrary direction when the passage of the electricity was suddenly interrupted. These transitory currents, resembling waves, were found to be capable of magnetizing needles placed within the helix. Collateral currents, either in the same or in opposite directions, exert no permanent inductive power on each other.

No other evidence of the electric action of these induced currents could be detected, such as the appearance of a spark, the ignition of fine wires, or of charcoal, impressions on the tongue, contractions in the muscles of frogs, or chemical decompositions. Yet these induced currents were found to be capable of passing through fluids, when interposed to a small extent in the circuit.

Similar effects were apparently produced by the inductive influence of ordinary electricity directed through the first set of wires.

The second part of this paper contains the account of experiments in which the helix connected with the voltaic battery was wound round one side of an iron ring, welded from soft round bar-iron; while another helix connected with a galvanometer was coiled round the opposite side of the ring. The electrical indications obtained by this apparatus were much more considerable than in the former case, but were equally transitory, and were of opposite kinds on the interruption of the contacts with the battery. By interposing charcoal points in the circuit of the induced helix, a minute spark was perceived whenever the contacts were made or broken off; but no ignition of wires or other electric effects could be obtained. Electric currents were also induced in a helix into which a soft iron cylinder was introduced, whenever that iron was rendered magnetic by induction from magnets applied to its ends. The sudden introduction or removal of a magnet, in the place of the iron cylinder, produced similar effects on the helix.

In many of these experiments the author employed the large compound magnet constructed by Dr. Gowin Knight, and belonging to the Royal Society. Similar effects were produced when the iron was surrounded by a piece of copper plate wrapped once round it with its edges connected with the wires of the galvanometer. Currents were induced on a wire coiled into a flat spiral, by bringing one of the poles of the powerful magnet of Dr. Knight opposite to its centre. Even single wires brought near the pole of this magnet had electric currents induced in them. But all attempts to obtain chemical effects by these currents of electricity induced by magnetism were unsuccessful.

In the third part of the paper the author regards the condition in which a conducting wire exists while it is subject either to volta-electric, or magneto-electric induction, as a peculiar one, which he designates by the term *Electro-tonic state*. This peculiar condition shows no electrical effects while it continues, nor does it exert any sensible action on matter, or on other electrical currents, either of an attractive or repulsive kind; nor does it tend either to accelerate or to retard those currents.

In the fourth part of the paper the author relates a great number of experiments, which concur in proving that when a piece of metal is moved in any particular direction, either in front of a single magnetic pole, or between the opposite poles of a horse-shoe magnet, electrical currents are developed which pass along the substance of the metal in a direction transverse to that of its own motion. By the application of this principle, the author is enabled to explain the various phenomena which take place in the experiments of Arago and others, where magnetic action appears to be developed by rotation; and which have been erroneously attributed to simple magnetic induction, and to the time supposed to be required for the progress of that induction. The electro-magnetic effect of the electric current induced in a conductor by a magnetic pole, in consequence of their relative motion, is such as tends continually to diminish that relative motion; that is, to bring the moving bodies into the state of relative rest; so that if the one be made to revolve by an extraneous force, the other will tend to revolve with it in the same direction, and with the same velocity.

A paper was read, entitled "Some Remarks on the internal Structure of the Platypus Anatinus (*Ornithorhynchus paradoxus*, Blum.)." By Richard Griffin, Esq. Communicated by Dawson Turner, Esq. F.R.S.

Having an opportunity of examining two specimens of the *Ornithorhynchus*, the one male, the other female, belonging to the Norfolk and Norwich Museum, the author found in the latter two large mammary glands, one on each side of the chest, and covering nearly the whole under surface of the animal; numerous ducts proceeded from them, perforating the skin, at two circular portions, which presented no elevation corresponding to nipples. The Fallopian tubes terminate by very small orifices in the cloaca: posterior to their terminations the author observed two slightly projecting processes, containing each the orifice of a duct which proceeds to a length of at least two inches, but the continuation of which could not be traced in the specimen examined in consequence of the injuries it had received. In the male, three pointed processes were noticed at each extremity of the corpora cavernosa of the penis, the cavities of which do not communicate with one another, and are separated before their termination. The spur of the male is furnished with a sac, of the size of a pea, containing a poisonous fluid, which by means of a canal is conducted into a wound inflicted by the spur.

December 22, 1831.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The Right Hon. Sir James Graham, Bart. was elected a Fellow of the Society.

A paper was read, entitled "Some Account of a New Volcano in

the Mediterranean." By John Davy, M.D. F.R.S. Assistant Inspector of Army Hospitals.

The first intelligence of the breaking out of the volcano, which is the subject of the present paper, was brought to Malta, on the 16th of July last, by a merchant vessel. It was confirmed soon after by Captain Swinburne, of H.M.S. *Rapid*, who had succeeded in approaching very near the island. The crater of the volcano, which was in great activity, was then only a few feet above the level of the sea. Several shocks of an earthquake had been felt near the same spot about a month before the eruption. The volcano continued active till the 16th of August, and the island it was forming gradually enlarged in all its dimensions; but since that period there has been no fresh eruption. In the end of August, a survey of the island was carefully made by Captain Wodehouse, R.N. of H.M. brig *Ferret*; and a plan drawn by him is annexed to the present paper. The circumference of the island is about 3240 feet, and its greatest height 107 feet; the circumference of its crater is about 780 feet. The surface of the island is composed entirely of ashes and cinders, without any lava. The crater contained turbid salt water, having a temperature of 200° Fahr. and emitting a constant supply of gas. The water in the immediate neighbourhood of the island was very shallow, not exceeding three or four feet, and the crater was rapidly filling up by the falling in of its margin.

The author could not learn that anything unusual had been noticed as having occurred in any of the neighbouring volcanic regions, either at the time of the eruption or immediately antecedent to it. He describes the phenomena, which fell under his own observation, on a visit which he made to the island on the 5th of August. During the most violent eruptions, a large quantity of dense white vapour, resembling snow or bleached wool, rose to a great height in the atmosphere, and assumed various extraordinary forms; this was followed by columns of perfectly black matter, rising to the height of three or four thousand feet, and spreading out very widely, even to windward. The subterranean sounds attending the eruptions were not very loud, and were much exceeded by that of the electrical explosions accompanying the lightning, which was seen to dart in various directions in the atmosphere of the eruption. To leeward of the volcano, the sea was much discoloured by the admixture of ashes and fine dust, and an abundance of light cinders were floating on its surface. Even when the author was enveloped in the dark cloud of ashes falling from the volcano, not the smallest odour of bitumen, of sulphuretted hydrogen, or of sulphureous or any other acid, was perceptible; nor was any inconvenience felt in respiration. No appearance of flame, and but little light, was exhibited during these eruptions.

The solid products ejected from the volcano appeared, on examination, to differ more in form than in chemical composition; and were found to consist of alumina, lime, magnesia, and silice, coloured by protoxide of iron, and without any potash. With the exception of small masses of vesicular basalt, similar to the common lava of Etna and Vesuvius, these materials exhibited no crystalline structure. The

water taken from the crater appeared to consist of sea-water holding in suspension a fine dust, together with filaments resembling vegetable fibres, which the author supposes to have been derived from sea-weed drawn into the water. The saline ingredients of this water differed from that of the Mediterranean, chiefly in containing more sulphate of lime, and a little alumina, oxide of iron, and a trace of oxide of manganese; all these in combination with an acid, probably the sulphuric or muriatic, and a notable portion of hypersulphite of lime and magnesia. He could not detect in it any free acid or alkali, or the presence, even in combination, of any potash or ammonia, or nitric acid, nor the slightest trace of bromine or iodine. The gas emitted by the volcano appeared, as far as could be determined from an examination of two specimens, to consist chiefly of carbonic acid, with a trace of sulphuretted hydrogen.

The author observes in conclusion, that the results of his inquiry are almost entirely of a negative kind; and in this respect correspond with those obtained by Sir Humphry Davy, with respect to Vesuvius, and which are described in his paper "On the Phænomena of Volcanos," published in the Philosophical Transactions for 1828. They accordingly tend to corroborate the simple hypothesis there adopted in explanation of the phænomena of volcanic action; namely, that of the existence of an ignited nucleus of fluid matter, occasionally forced through the cooled crust of the earth by the expansive power of steam and gas: and they militate strongly against the hypothesis of the chemical origin of volcanos, and of their being attended by a decomposition of water by the metallic bases of the earths and alkalies.

A drawing of the volcano in its active state of eruption accompanied the paper, together with a plan and views of the island.

January 12, 1832.

JOHN BOSTOCK, M.D., Vice-President, in the Chair.

The Bakerian Lecture for 1832, entitled "Experimental Researches in Electricity—Second Series," by Michael Faraday, Esq. F.R.S., was read.

The success of the author in exhibiting the evolution of electricity by induction from ordinary magnets, led him to conclude that similar effects might be obtained from the magnetism of the earth, and even to an extent that might render it available in the construction of new electrical machines. These expectations have been fully realized; and the researches which establish the influence of terrestrial induction in giving rise to electrical currents, form the subject of this second paper.

Whenever a hollow helix, the terminal wires of which were connected with those of a galvanometer, and which inclosed a cylinder of soft iron, was held with its axis in the line of the magnetic dip, and suddenly inverted, the evolution of electric currents was immediately rendered sensible by the deflection of the needle of the galvanometer; a deflection in the contrary direction being produced the moment the helix was again inverted, so as to recover its first

position. The same effect resulted from the simple introduction of the iron cylinder into, or its removal out of, the helix; evidently in consequence of the magnetism acquired by position with relation to the magnetic poles of the earth. When a cylindric magnet was substituted for the soft iron, the same phænomena, obviously ascribable to terrestrial induction, were in either case observed. Similar but more feeble indications of the same effect were obtained by inverting the helix alone, without its association with any ferruginous body whatever.

The influence of terrestrial magnetism in eliciting electricity from revolving metallic bodies was next made the subject of investigation. A copper plate was made to rotate in a horizontal plane, one of the wires of the galvanometer being brought into contact with its axis, and the other attached to a leaden conductor pressing against the amalgamated edge of the plate. The needle of the galvanometer was immediately deflected, either to the east or west, according to the direction of the rotation; and by successively changing this direction, and accommodating it to the oscillations of the needle, the arc of its vibrations was soon made to extend to 50° or 60° . When the plane of rotation passed through the line of dip, the galvanometer was not affected. A copper plate, revolving in a plane perpendicular to the line of dip, thus composes a new electrical machine, differing from the common plate machine in the circumstance of the material of which it is formed being the most perfect conductor, while in the latter it is the most perfect non-conductor. Insulation, which is essentially required in the latter, is fatal to the efficacy of the former. The quantity of electricity produced by the metallic machine does not appear to be inferior to that evolved by the glass machine, although differing much in its intensity. On employing copper wires of greater thickness, more powerful effects were obtained. The author expects that the effects may be still further increased by certain combinations of superposed plates, alternately revolving in opposite directions.

The author proceeds to show by experiment the manner in which terrestrial magneto-electric induction produces phænomena similar to those observed by Messrs. Barlow and Christie when ferruginous bodies are in rapid rotation, and which have been ascribed to a change in the ordinary disposition of the magnetism of the ball. He found that the rotation of a copper ball on an axis either horizontal or otherwise inclined to the line of dip, gave rise to a circulation of electric currents in a plane perpendicular to that of revolution, and in exact conformity with the law already deduced by the author in the first part of this paper. This law is illustrated in a very simple manner by the following experiment.—A copper wire, eight feet long, had its two ends fastened, each respectively to the ends of the wires of the galvanometer, so as to form with them one uninterrupted circuit. Upon moving the copper wire to and fro over the galvanometer, whilst the lower part remained steady, the magnetic needle was immediately deflected, in a direction regulated by the relative position of the wire and the direction of its motion.

It is a further consequence of this law, that the rotation of the globe of the earth itself must tend to induce electric currents in its own mass, passing in each hemisphere from the equatorial to the polar regions; so that if one set of conductors could be applied at the equator, and another at the poles, negative electricity would be collected by the former, and positive electricity by the latter. The electricity of metalliferous veins in the mines of Cornwall (of which an account has been given by Mr. Fox, in a paper lately published in the Philosophical Transactions,) does not appear, however, to be referrible to magneto-electric induction. It may be a question whether the phenomena of the Aurora Borealis and Australis may not arise from the discharge of this induced electricity consequent on the earth's rotation.

As it appeared probable that there exists some natural difference in the intensity of these electric currents induced by magnetism in different conducting bodies, the author endeavoured to determine what effects might arise from this difference in the case of iron and copper. For this purpose he joined together the ends of wires of each of these metals, each 120 feet in length, extended in the direction of the magnetic meridian. The copper wire was then divided in the middle and examined by a delicate galvanometer, but no evidence of any electrical current was obtained. The same negative result attended trials with wires of these metals, twisted together, and passed between the poles of a powerful magnetic battery. Similar experiments tried with other metals, and also with a circuit composed of copper and sulphuric acid, afforded in like manner no indications of electric currents. Hence it appears that when metals or other conductors of different kinds are equally subjected to magneto-electric induction, they exhibit equal powers with respect to the currents induced in them.

By another experiment the author shows that these effects of magneto-electric induction are not owing to the motion of the magnet and conductor relatively to each other, but that they take place to an equal degree when the two are united so as to revolve together, and when, consequently, they are relatively at rest. Electric currents are produced also in the substance of the magnet itself, simply by revolution on its own axis while floating on mercury, and the circuit completed by wires making a communication between the mercury and the axis of the magnet.

The author has comprised the phenomena here related in the following general formula. Referring to the pole of the magnet as the centre of action, if all the parts of the metallic conductor move in the same direction and with the same angular velocity, no electric currents are produced: but if one part cut the magnetic curves while another part is stationary, or if the motion of the whole be in one direction, but its angular velocity relatively to the pole of the magnet be different, then, in either case, currents will be produced; the maximum effect taking place when different parts move in different directions across the magnetic curves.

January 19, 1832.

JOHN BOSTOCK, M.D., Vice-President, in the Chair.

A paper was read, entitled "On the theory of the Perturbations of the Planets." By James Ivory, Esq. A.M. F.R.S., Instit. Reg. Sc. Paris., & Reg. Sc. Götting., Corresp.

The methods hitherto employed by mathematicians for determining the variations which the elements of the orbit of a planet undergo in consequence of perturbation, and for expressing these variations analytically in the manner best adapted for computation, are found to depend upon a theory in mechanics, of considerable intricacy, known by the name of the *Variation of the Arbitrary Constants*. In seeking the means for abridging the severe labour of the calculations, we must separate the general principles on which they are founded from the analytical processes by which they are carried into effect; and in some important problems great advantage is obtained by adapting the investigation to the particular circumstance of the case, and attending solely to the principles of the method in deducing the solution. The author suggests the possibility of simplifying physical astronomy by calling in the aid of only the usual principles of Dynamics, and by setting aside every formula or equation not absolutely necessary for arriving at the final results.

The present paper contains a complete determination of the variable elements of the elliptic orbit of a disturbed planet, deduced from three differential equations, that follow readily from the mechanical conditions of the problem. In applying these equations the author observes, the procedure is the same whether a planet is urged by the sole action of the constant force of the sun, or is besides disturbed by the attraction of other bodies revolving round the luminary; the only difference being that, in the first case, the elements of the orbit are all constant, whereas in the other case they are all variable. The success of the method followed by the author is derived from a new differential equation between the time and the area described by the planet in its momentary plane, which greatly shortens the investigation by rendering it unnecessary to consider the projection of the orbit. But the solution given in the present paper, although it makes no reference to the analytical formulæ of the theory of the *Variations of the Arbitrary Constants*, is no less an application of that method and an example of its utility, and of the necessity of employing it in very complicated problems.

January 26, 1832.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer,
in the Chair.

The reading of a paper, entitled "Experimental Researches in Voltaic Electricity," by the Rev. William Ritchie, LL.D. F.R.S. Professor of Natural and Experimental Philosophy in the Royal In-

stitution of Great Britain, and in the University of London, was commenced.

February 2, 1832.

WILLIAM GEORGE MATON, M.D., Vice-President,
in the Chair.

Charles Octavius Morgan, Esq., Joseph Jackson Lister, Esq., William Gravatt, Esq., the Hon. William Francis Spencer Ponsonby, Captain Sir Samuel John Brooke Pechell, R.N., Frederick Madden, Esq., John Edward Gray, Esq., and Alexander Barry, Esq., were elected Fellows of the Society.

The reading of the Rev. Dr. Ritchie's paper, entitled "Experimental Researches in Voltaic Electricity," was concluded.

The author adduces many facts in refutation of the theory by which Volta endeavoured to explain the development of electricity in galvanic circles. He shows that the contact of dissimilar metals is not necessary for producing that effect, for galvanic action may be obtained by employing only one metal, if the two ends of the same copper wire be coiled into helices of different diameters, and immersed into dilute nitric acid. The experiments of Mr. Parrot of St. Petersburg are cited as leading to results totally different to those on which Volta rested the foundations of this theory. The author points out several important marks of distinction between voltaic and common electricity, and denies that the latter is capable of passing into the former. He shows by an experiment that the free electricity developed by heat is independent of that developed by galvanic action. Chemical decompositions are effected in a totally different manner by voltaic and by ordinary electricity; for in the former case the two elements of the decomposed substance are found disengaged at the opposite poles, but in the latter they are developed at the same point, and appear more as the effect of a cleavage of the molecules by the mechanical agency of electricity. The author conceives that in a galvanic circle of zinc and copper with interposed water, the superior attraction of the zinc for oxygen produces an arrangement of the molecules of the water such that the particles of oxygen entering into the composition of each are all turned towards the zinc. This definite arrangement produces in its turn, by production on the neutral electric fluid contained in the metal, a corresponding definite arrangement of the two electricities along the whole electric circuit. Hence electro-magnetic effects may be obtained without any chemical decomposition; this latter effect taking place only when the attraction of the metal for one of the elements of the fluid is greater than that between the two elements of the fluid: and upon this principle the author conceives that the phenomena of the secondary piles of Ritter, and those observed by M. de la Rive, may be explained. By adopting the theory of the successive decomposition and recomposition of each particle of fluid in the line of action, we avoid the necessity of supposing the transference of the disengaged element through the intervening

mass of fluid. Whatever circumstance favours the decomposition of the water, will also increase the power of the voltaic arrangement. Conformably to these views we find that all liquids whose component parts go to the same pole are non-conductors of voltaic electricity. A given section of a liquid is capable of conducting only a limited quantity of electric influence. It was also found by experiment that when sulphuric acid was employed, the quantity of electro-magnetic action in the connecting wire is exactly proportional to the quantity of water decomposed in the liquid part of the circuit. This quantity is, within certain limits, inversely proportional to the square root of the distance between the plates.

In the second part of this paper the author enters upon an investigation of the fundamental principle and laws of action of the voltaic battery. He calls in question the truth of the common theories of galvanism, which are founded on the supposition of electricity being accumulated in the poles of the battery before the circuit is completed, and of its actual transfer and continued circulation through the entire course of the circuit. In order to analyse the effect of a single galvanic circle, the author made the following experiments. A compound plate of zinc and copper soldered together was cemented into a trough, and two single plates of copper of the same size were cemented, one on each side of the former plate, into the same trough, so as to form a cell on each side of it; and the cells were filled with dilute acid. On connecting the extreme copper plates by metallic wires with a delicate torsion galvanometer, a certain deflection of the needle was produced. When two compound plates were placed between the terminal copper plates, the deflection was twice as great; when three were employed, it was three times as great, and so on. It is thence inferred that the voltaic effects of two batteries of the same length, and with plates of the same size, are directly proportional to the number of plates. By prosecuting this inquiry, the author finds that, within certain limits, the voltaic energies of two batteries, consisting of plates of the same size, and placed at equal distances, but differing in number, are very nearly proportional to the square root of the number of plates. This result was deduced both from the quantity of water decomposed by the apparatus, estimated by the quantity of hydrogen disengaged, and also by the electro-magnetic effects, as measured by the torsion galvanometer. But when the number of plates is greatly extended, the above law of increase is no longer observed, the effect being less than in proportion to the square root of the number. By continuing to increase the number of plates, we at length reach a limit beyond which there is no increase of effect, but rather a diminution. So that if the voltaic power were represented by the ordinates of a curve of which the abscissa denoted the number of plates, the curve, from being at first a parabola, would afterwards deviate into a form approaching to that of an ellipse.

In the third part of the paper the author relates experiments which prove that every part of the galvanic circuit conducts the same quantity of electricity, whatever be the material, whether solid or fluid,

composing it; for the magnetic needle is deflected in an equal degree by every part. He succeeded in exhibiting the rotation of a piece of charcoal, and of a column of water, while transmitting voltaic electricity, round the pole of a magnet. Having noticed a difference of temperature in the fluid conductor in the vicinity of the two poles, he was led to investigate the cause of this phænomenon. A rectangular box being divided into three compartments by two partitions of bladder, and filled with water, and the wires from the two poles of the battery being inserted into the extreme compartment, the temperature of the water surrounding the positive pole was found to be higher than that surrounding the negative pole, and that in the middle compartment highest of all. These differences he ascribes to the cooling effects of the disengagements of the several gases at each respective pole, the volume of the hydrogen being double that of the oxygen, producing twice the effect. With metallic solutions, the reverse takes place, the effect depending in every case upon the relative specific heat of the substances disengaged at the two poles.

The reading of a paper, entitled, "On the Organs of the Human Voice," by Sir Charles Bell, Knt. K.H., F.R.S., was commenced.

February 9, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

A paper was read, entitled, "Some remarks on an Error respecting the Site and Origin of Graham's Island." By Capt. W. H. Smyth, R.N. K.F.M. F.R.S.

The author rectifies an erroneous assertion, originating from the report of Captain Larmour, who in the year 1800, when commanding the *Wassanaer*, a troop-ship on the Egyptian expedition, thought he observed a shoal of four fathoms water with breakers, within a mile of the latitude and longitude of the new volcanic island. The author has determined, by his own observations, that no such reef exists in that spot, nor is the assigned place of this shoal near that of Graham's Island, which arose considerably to the eastward, from a depth of above a hundred fathoms below the surface of the water. A knoll, with only seven fathoms of water upon it, was discovered not far from the site of these reports. The Adventure bank extends from Sicily nearly to Pentellaria, where the water deepens at once from 76 fathoms to above 375 fathoms, at which no bottom was met with. But, even on the supposition that what Capt. Larmour imagined he saw was the result of a temporary subaqueous volcanic eruption, it could not have justified the assertion of there being breakers with four fathoms upon them; and still less does it afford any foundation for the hypothesis that Graham's Island was formed by the mere lifting up of such shoal.

A paper was also read, entitled, "Researches in Physical Astronomy." By J. W. Lubbock, Esq. M.A., V.P. and Treas. R.S.

For the solution of mechanical problems, two methods in general present themselves : the one furnished by the variation of parameters, or constants, which complete the integral obtained by the first approximation,—the other furnished by the integration of the differential equations by means of indeterminate coefficients, or some equivalent method. Each of these methods is applicable to the theory of the perturbations of the heavenly bodies, and they lead to expressions which are of course substantially identical, but which do not appear in the same shape except after certain transformations.

The object of the author in the present paper is to effect transformations, by which their identity is established, making use of the developments given in his former papers, published in the *Philosophical Transactions*. The identity of the results obtained by either methods affords a confirmation of the exactness of those expressions.

Sir Charles Bell's paper "On the Organs of the Human Voice" was then read in continuation.

February 16, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The reading of Sir Charles Bell's paper "On the Organs of the Human Voice" was resumed and concluded.

The author complains that the actions of the organs of the voice have been negligently treated by physiologists, and that many of the offices of the structures subservient to that function have been overlooked; and expects that the study of them will lay a foundation for prosecuting the intricate anatomy of the nerves of the neck, which he proposes to himself as an ulterior object. The subjects to which he particularly directs his attention in the present paper, are the Muscularity of the Trachea, the Position of the Thyroid Gland, and the Action of the Pharynx, which he alleges to have been entirely omitted in previous systematic accounts of articulate language.

The trachea is strengthened by imperfect circles of cartilage, the ends of which are united at the back part of the tube by a transverse layer of muscular fibres,—a structure which is very distinctly seen in the horse. This transverse muscle is an antagonist to the elasticity of the cartilages, and the effect of its action during expiration is, by contracting the diameter of the tube, to favour the propulsion of the mucous secretion, which may have been accumulated in the passage, and to contribute effectually to expel it by the effort of coughing. The same action leads also to the expulsion of foreign bodies which may have accidentally got into the trachea. In birds, where the inner surface of the passage is without moisture, no such provision was required; and accordingly we find the cartilages of the trachea are complete circles, not admitting of contraction.

The author considers the thyroid gland as serving the purpose of interrupting the vibrations of the cartilages of the trachea, to which it is closely attached, especially when pressed against it by the actions of the flat muscles which extend over it. If sound were given out by the vibrations of the trachea, it would interfere with the distinctness of the voice. The thyroid gland is, therefore, placed low in the larynx, and on the upper part of the trachea, for the purpose of checking the vibrations of that tube, and suppressing the sounds that would thence be produced. In birds, where the voice originates in the inferior larynx, and is propagated along the trachea, the structure of that tube is adapted to vibration, the circles of cartilage being complete, and there is no thyroid gland.

In man, the primary source of the voice is the vibration of the chordæ vocales, or ligaments of the glottis, acted upon by the impulse of the air passing by them. The proper degree of tension is given by these ligaments by the action of the muscles, which adjust their position with the greatest accuracy. The movements of the chest, which regulate the expulsion of the air, are at the same time adapted with great nicety to the production of the required effect. The sacculi laryngis also contribute to give greater extent and freedom to the vibrations of the glottis. It is by the concurrent action of these organs that the breath, which under ordinary circumstances of respiration is inaudible, becomes *vocalized*, or thrown into sonorous undulations.

The author then gives an anatomical description of the pharynx and mouth, which together constitute an irregular cavity, extending from the glottis to the lips and nostrils, and of which the various changes of dimension and of form effect corresponding changes in the undulations into which the air is originally thrown by the vibrations of the glottis, and produce the different modifications of the voice. The most important are those which constitute articulate sounds. The simple vocal tones, or vowels, are greatly modified by the mere elongation or shortening of this cavity. But even in the formation of these, the contraction and appulse of the pharynx acts an important part; and in the articulation of the consonants it is a principal agent; its smaller cavity being, upon a well-known hydrostatic principle, substituted with great economy of power for the more capacious cavity of the chest. In pronouncing the explosive consonants, such as B, D, and G, the velum pendulum is raised, and, acting as a valve, closes the posterior nares; and the mouth being also closed, the vocalized breath, which continues to ascend through the glottis, suffers condensation, and gives rise to the faint sound which precedes the explosion consequent upon the opening of the closed cavity. This opening takes place, either by the separation of the lips, or by the removal of the tongue from the teeth, or palate, to which it had been applied. These previous actions of the pharynx and glottis are the circumstances which distinguish the sound of these letters from their corresponding mute consonants, P, T, and K. Thus the consonants, classed according to their formation in the mouth, either by the closed lips, the meet-

ing of the lips and teeth, or the meeting of the tongue and palate, admit of varieties dependent on the actions of the pharynx and velum palati. The emphasis and accent given to particular syllables arise from two sources: namely, the variation in the action of the chest, and in the action of the pharynx.

This minute accommodation of action evinces not merely the perfection of the organ, but also its great subordination to the will; and in this respect the muscular apparatus of the throat admits of comparison with the delicate adjustments in the eye. Stammering arises, not from the defect in any single part, but from imperfect power of combining the requisite actions.

The author concludes by enumerating the variety of actions which must be combined before a word is uttered: namely, the compression of the thorax, the adjustment of the glottis, the elevation or depression of the larynx, and the contraction of the pharynx. He also adduces proofs of the correctness of the opinions advanced in this paper, drawn from the effects of accident and of disease occurring under his own observation; and from which he draws the following conclusions:—That the trachea gives out no sound of itself; that when the area of the passage is much diminished, the column of air has not sufficient force to move the chordæ vocales; that whatever interferes directly with the motion of the glottis reduces the voice to a whisper; that any permanent opening or defect of the velum, which prevents the distention of the pharynx and the closing of the posterior nares, renders articulation defective; that the obstruction or removal of the cells of the face deprives the voice of its body and clearness; and that nervous relaxation of the muscles of the throat is productive of great alteration in the voice. Hence the author infers the necessity of the numerous nerves which are distributed to these organs.

February 23, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The reading of a paper, entitled, "On the Inverse Ratio which subsists between Respiration and Irritability in the Animal Kingdom; and on Hybernation," by Marshall Hall, M.D. F.R.S.E., communicated by J.G. Children, Esq. Sec. R.S., was commenced.

March 1, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

Dr. Hall's paper was resumed, and read in continuation.

March 8, 1832.

WILLIAM GEORGE MATON, M.D., Vice-President,
in the Chair.

The reading of Dr. Marshall Hall's paper, entitled, "On the Inverse Ratio which subsists between Respiration and Irritability in the Animal Kingdom; and on Hybernation," was concluded.

The object of the author, in the investigation which he has undertaken, and of which some of the results are given in the present paper, is to establish a law of the animal economy, which he expresses in the following terms: "The quantity of the respiration is inversely as the degree of the irritability." Other authors, such as Cuvier, attaching a different meaning to the term *irritability*, have stated this property, in the different classes of animals, as being directly proportional to the energy of the respiratory functions; the purposes of which they have considered to be those of restoring to the exhausted muscular fibre its contractile power. The author of the present paper regards animal life as consisting in two essential ingredients; namely, stimulus and irritability; atmospheric air being the principal source of the former; the heart, where it exists, being the principal organ of the latter; and the blood being the medium by which these are brought into contact.

For the purpose of ascertaining the quantity of respiration in any given animal, the author contrived an apparatus, to which he gives the name of the '*Pneumatometer*'. It consists of a glass jar inverted over mercury, and over the mouth of a bent tube, by which it communicates with a water-gauge of one tenth the capacity of the jar. Annexed to this apparatus, but unconnected with it, is a glass ball, containing ten cubic inches, and terminating in a tube, bent at its upper part, and of the capacity of one cubic inch, and inserted into a wider tube containing water, so as to correspond in all its pneumatic conditions with the jar and its gauge, and to point out whatever changes may have taken place in the volume of the air examined in the course of the experiment, from circumstances extraneous to it, such as variations of temperature, or of barometrical pressure. The animal, whose respiration is to be examined, is placed on a stand and covered with a jar; and the carbonic acid produced is absorbed by pieces of calico moistened with a strong solution of caustic potass, fixed by a wire frame in the upper part of the jar. The animal, at the end of the experiment, is withdrawn under mercury, without displacing the jar; the space it had occupied is filled with an equal volume of atmospheric air admitted into the jar; and the volume of oxygen gas absorbed is estimated by the column of water which has risen in the gauge.

From the facts detailed by Harvey, Goodwyn and others, which establish that in asphyxia the left ventricle of the heart ceases to contract before the right ventricle, the author infers that the irritability of the latter is greater than that of the former; and proposes to distinguish the first as *arterio-contractile*, and the latter as *veno-*

contractile, from the circumstance of their being stimulated respectively by arterial and by venous blood. He considers the power of bearing suspended respiration as a *measure* of irritability, which may be expressed by the length of time during which an animal can support the suspension of this function. He then shows that, conformably to these definitions, the *foetus* before birth, the reptile, and the molluscous animal possess a much higher degree of irritability than the adult, or than animals belonging to the class of mammalia and birds; in which the quantity of respiration being very great, the irritability is proportionally small.

He then proceeds to consider the *phænomena* of hybernation; and shows that they are very similar to those of the ordinary sleep of the same animals, but differ from those of the sleep of animals which do not hybernate. In the former case the respiration is nearly, if not wholly, suspended, and the temperature greatly reduced; but the circulation continues unimpaired. He notices differences also in the habits of different hyberating animals, some of which frequently awake from their slumber during the winter, while with others the lethargy is uninterrupted. The state of hybernation should, he thinks, be carefully distinguished from the torpor induced by excessive cold; the former being a conservative, the latter a destructive process. The exclusion of atmospheric air, which is speedily fatal to the animal in its active state, is sustained with perfect impunity during hybernation, the respiration being then entirely suspended. The animal being at such times reduced to a state analogous to that of the reptile, but in a still higher degree, the irritability is much increased: the heart continues to beat without the stimulus of aerated blood, and the circulation is kept up with perfect regularity. This latter fact was ascertained by actual observation in the case of the bat, by adjusting the wing of the animal, so as to admit of its being placed in the field of a microscope without disturbing its repose. The experiments of Mangili are quoted in proof of the longer continuance of the action of the heart after decapitation, if the experiment be made in the hyberating state, than if it be made when the animal is in its ordinary state of activity.

Animals, during hybernation, are easily roused from their lethargy, and restored to sensibility and activity; and the muscles do not appear to be affected with the slightest rigidity: the respiration is immediately resumed, and the temperature rises rapidly to the natural standard. The hedgehog and the dormouse awake periodically from the sense of hunger, and the food then taken conduces to renewed lethargy. But frequent excitation from this state is productive of great exhaustion, and is often fatal to the animal. Severe cold, like other causes producing a painful impression, rouses the hyberating animal from its state of lethargy; and if continued, induces a state of torpor, which ends in death.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1831-1832.

No. 9.

March 15, 1832.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer,
in the Chair.

A Paper was read, entitled "Further Notice of the new Volcano in the Mediterranean." By John Davy, M.D. F.R.S. Assistant Inspector of Army Hospitals.

The author states that since the 25th of October, the date of his last communication to the Society, the crater of the volcano has undergone several changes of form, and has now entirely disappeared. He infers from the phenomena observed, that the crater was one of *eruption*, composed entirely of loose materials, thrown up by volcanic action, and not one of *elevation*, that is, formed of rock which once composed the bed of the sea. In July the heat at Malta was very close and oppressive, the thermometer rising more than once to 105° of Fahrenheit, and the western sky had a dark lurid red hue: but these atmospheric states are regarded by the author as independent of the volcano, for the temperature of the air in its immediate vicinity was very little affected by it.

A Paper was also read, entitled "A method of deducing the Longitude from the Moon's Right Ascension." By Thos. Kerigan, R.N. Communicated by Admiral Sir Edward Codrington, F.R.S.

The author has recourse to the moon's right ascension as an element for determining the true meridian of the place of observation: his method being an extension of that given by him in the first volume of his "Mathematical and General Navigation Tables." He gives examples of the application of this method, and considers that with the aid of a chronometer showing the approximate mean time at Greenwich, the longitude of any given place may be determined, either at sea or on land, within very narrow limits of error, and with much greater practical convenience than by the ordinary method of lunar distances.

March 22, 1832.

The Rev. WILLIAM BUCKLAND, D.D. Vice President,
in the Chair.

The reading of a Paper, entitled "An Account of some experiments and observations on the Torpedo," by John Davy, M.D. F.R.S. Assistant Inspector of Army Hospitals,—was commenced.

March 29, 1832.

GEORGE RENNIE, Esq. Vice President, in the Chair.

The following Report, drawn up by the Rev. William Whewell, M.A. F.R.S., and John William Lubbock, Esq. M.A. V.P. and Treasurer R.S., on Professor Airy's Paper, read before the Royal Society on November 24, 1831, and entitled, "On an Inequality of Long Period in the Motions of the Earth and Venus," was read.

Report.

The object of this memoir is similar to that of Laplace's celebrated investigation of the great inequality of Jupiter and Saturn, announced in the Memoirs of the Academy of Sciences for 1784, and given in the volume for the succeeding year. The occasion of that investigation was an acceleration of the mean motion of Jupiter and a retardation of that of Saturn,—which inequalities in the motions of the two planets Halley had discovered by a comparison of ancient and modern observations : and Laplace showed, in the Memoirs just referred to, that inequalities like those thus noticed would arise from the action of gravitation ; that they would reach a considerable amount in consequence of twice the mean motion of Jupiter being very nearly equal to five times the mean motion of Saturn ; and that their period would be nearly 900 years. The occasion of the investigation of Professor Airy was an inequality in the sun's actual motion, as compared with Delambre's Solar Tables, which appeared to result from a comparison of late observations with those of the last century,—as Professor Airy has explained in a memoir published in the Philosophical Transactions for 1828. This comparison having convinced him of the necessity of seeking for some inequality of long period in the earth's motion, it was soon perceived that such an inequality would arise from the circumstance that 8 times the mean motion of Venus is very nearly equal to 13 times the mean motion of the earth. The difference is 1,675 centesimal degrees in a year,—from which it follows, that if any such inequality exist, its period will be about 240 years.

To determine whether such an inequality arising from the action of gravitation, amounts to an appreciable magnitude, is a problem of great complexity and great labour. The coefficient of the term will be of the order 13 *minus* 8, or 5, when expressed in terms of the eccentricities of the orbits of the Earth and Venus, and their mutual inclination ; all which quantities are small ; and the result would therefore, on this account, be very minute. But in the integrations by which the inequality is found, the small fraction expressing the difference of the mean motions of the planets enters twice as a divisor ; and by the augmentation arising from this and other parts of the process, the term receives a multiplier of about 2,200,000. In the corresponding step of the investigation of the great inequality of

Jupiter and Saturn, it was only necessary to take terms of the 3rd order of smallness, and the multiplier by which the terms are augmented has 30^2 instead of 240^2 for its factor.

In the present state of physical astronomy methods exist by which the results of the law of universal gravitation in the planetary system may be obtained to any degree of accuracy, by calculating in succession the terms of successive orders of minuteness, the order being estimated according to the powers and products of the excentricities of the orbits. But it is well known, that in the actual application of these methods, the number of the terms arising from the combination of the several series which occur, and the complexity of the operations by which the coefficients of these terms are to be deduced, increase so rapidly in passing beyond the lower orders of inequalities, that the calculation is difficult and laborious.

The numerical calculation of a perturbation depending on the 5th powers of the excentricities has not been executed, so far as we are aware, except in the case of the great inequality of Jupiter and Saturn, where, as Laplace states (*Mécanique Céleste*, p. ii. liv. 6. 9^c), this labour, "pénible par son excessive longueur," has been performed by Burckhardt with a scrupulous attention. And no calculation of a new inequality of a high order, requiring to be placed in the planetary tables, with a new argument, has been published since that of the great inequality by Laplace in 1784.

One of the main parts of the labour of such calculations consists in obtaining the successive terms of a certain quantity on which the perturbing forces depend, and which in the *Mécanique Céleste* is called R . This quantity is a function of the positions of the two planets which affect each other, and involves the reciprocal of the distance of the two bodies. It is to be expanded according to the powers and products of the excentricities and inclination of the two orbits, its successive terms having as factors the cosines of certain angles, all of which increase proportionally to the time.

It may be expanded by Taylor's theorem applied to several variables, according to powers of the excentricities, and f^2 , f being the sine of half the inclination*.

In this expansion the coefficients of the cosines of the different arguments are functions of certain quantities A or b (according to the notation of the *Mécanique Céleste*), and of the partial differential coefficients of these quantities with regard to a and a' , the radii of the orbits; admitting however of reduction so as to contain the differential coefficients with regard to one of these quantities only.

The quantity b is a function of $\frac{a'}{a}$, and has several values distinguished by different indices: these are connected by certain well-known equations of condition. The author of the present memoir obtains the development of R in terms of quantities C , sym-

* Laplace uses s , the tangent of the inclination. Burckhardt expresses himself to be in great doubt what function of the angle it is best to take.

metrical functions of a and a' ; and the different quantities C are of course connected by equations of condition similar to the others.

The general development of R , given in the third volume of the *Mécanique Céleste*, extends only to the terms depending on the squares of the excentricities. Burckhardt carried the development much further in the *Mémoires de l'Institut* for 1808; but Professor Airy's formulæ are not immediately comparable with his, on account of the employment of C instead of b . The formulæ of Burckhardt include however only 6 out of 12 of Professor Airy's coefficients, in consequence of the omission of terms depending on the inclination, by the former mathematician.

In the expansion of R , the terms which proceed according to the powers of the excentricities and of the sine of half the inclination (e, e', f), involve cosines of the multiples of V, T , and $V-T$, (V and T indicating the mean motions of Venus and the Earth with the addition of certain constant quantities.) By expanding also the variations of the radii vectores, which occur in these terms, according to powers of e, e' , the cosines of multiples of the arcs V and T again enter these terms. Hence the series will finally contain the products of the cosines of the three kinds of arcs, namely, multiples of $V-T, V$ and T ; which, as is well known, may be expressed in terms of the cosines of their sums and differences. These last arcs will produce various combinations of the form $pV - qT$. Of these we are to select those in which the arc is $13V - 8T$; for such terms will, in the calculation of the perturbations, be divided by very small quantities (namely, either $\frac{1}{240}$ or $\frac{1}{240^2}$), and may thus produce results of appreciable magnitude.

It may serve to assist us in forming a judgement concerning the place of Professor Airy's memoir among the laborious calculations of physical astronomy, if we compare it with the investigation of the great inequality of Jupiter and Saturn, as originally given by Laplace (*Mém. Acad.* 1785), the undertaking to which it has the closest analogy among such researches*.

The number of terms arising from the combination of the three arcs above mentioned, $V - T, V$, and T , which give $13T - 8V$, is considerable; but many of them are rejected on account of their coefficients going beyond the 5th order. The following six are retained and have their value calculated: those in which $V - T, V, T$ are respectively 8, 5, 0; 9, 4, 1; 10, 3, 2; 11, 2, 3; 12, 1, 4; 13, 0, 5. In the Jovi-Saturnian inequality, if V and T still refer to the mean motions of the exterior and interior planets, four combinations are taken, namely, those in which $V - T, V, T$ are respectively 2, 3, 0; 3, 2, 1; 4, 1, 2; 5, 0, 3.

The number of terms of the calculation depends also upon the

* The comparison is here made with the investigation of the *principal term* only of the Jovi-Saturnian inequality, as the most celebrated and most analogous, not as the most laborious or most recent, of similar investigations.

order to which it is carried. In Professor Airy's investigation there are, to each angular factor, *twelve* terms arising from the combinations of e, e', f ; in that of the inequality of Jupiter to the 3rd order, there are *four* such terms.

The number of the coefficients C , of the series for R , which it is requisite to calculate, depends both upon the number of effective combinations of arcs and the number of effective combinations of e, e', f . Hence the number of such coefficients, and their differentials, which Professor Airy's calculation demands, is very considerable. In the calculation for Jupiter, Laplace uses 6 coefficients b , and 14 of their differentials, in which however 28 differentials are virtually obtained. Professor Airy has occasion to use 70 values of C , the corresponding quantity in his process, and 98 of its differential coefficients; these quantities being calculated to a number of places from 7 downwards.

The calculation of the inequalities of the motions of Venus and the Earth, from the numbers thus obtained, requires the combination of these numbers with others depending on the excentricities, inclination, perihelia, and nodes of the orbits; and contains, as has already been said, 12 compound terms in the present investigation, and 4 in that of Laplace.

The greatest amount of the inequality thus explained by Laplace, was 20' for Jupiter and 47' for Saturn. The effect of the inequality examined in the memoir before us, would give an error in the geocentric longitude of Venus of between 20" and 30", if the mean motions of the Earth and Venus were determined, by comparing the observations about Bradley's time with the observations of a few years ago; and if the result were applied to calculate the next transit of Venus (in 1874).

The method adopted by Professor Airy in this investigation offers some peculiarities. There are two principal methods which may be employed in such problems: one is the method of *direct solution*, according to which the equations on which the inequalities depend are solved directly, and the values obtained by the first approximate solutions are substituted in the terms before neglected, in order to obtain a new solution. The other method is that of the *variation of parameters* (developed by Lagrange), according to which the planet, at any moment of time, is conceived to be moving in an ellipse, and the alterations are investigated which the elements of this ellipse must continually undergo, in order that the real motion may result. The former of these methods is the one which has generally been employed in calculating all inequalities of the planets except secular ones, and is used by Laplace in the theory of Jupiter and Saturn. In the present memoir the author has adopted the method of the variation of parameters, and he states his opinion that this, or some similar method, will ere long be adopted in the planetary theories, to the exclusion of other methods.

In one instance the author has introduced an alteration into the formulæ given for the variation of the elements by those who have

hitherto employed the theory of Lagrange. The differential $\frac{dR}{de}$, in Lagrange's method, implicitly includes the differential of R with regard to the mean motion. But it has been shown by Lagrange himself, and since him by others, that we may finally omit the term depending on the variation of n , if we use $\int n dt$ throughout instead of nt . This reduction Professor Airy does not adopt, retaining explicitly the term $\frac{dR}{dn}$.

This difference in the formulæ is equivalent to a change in the meaning of the term *epoch*. In determining the longitude of the epoch of the instantaneous ellipse, Laplace, and others who have followed Lagrange, fix it by supposing this longitude to be the angle which we must add to the angle described by the *variable* elliptical mean motion since the origin of the time, in order to have the mean anomaly in the ellipse. Professor Airy assumes the longitude of the epoch to be that angle, which we must add to the angle described by the instantaneous elliptical mean motion, considered *constant* since the origin of the time, in order to have the mean anomaly: the mean motion from the perihelion is, on the first supposition, $\int n dt + \varepsilon$, on the second, $nt + \varepsilon$. In the results of the calculations in these two ways there is no discrepancy, the difference of the formulæ and the difference of the suppositions necessarily balancing each other.

It may be observed, that according to the method of the variation of parameters, a large portion of the inequality, in the present instance, falls upon the longitude of the epoch. The coefficient of this inequality is something more than $2''$; which produces nearly the same maximum amount in the longitude of the planet, the effects of the variations of the other elements being insensible.

In investigations of such extent and complexity as the one now before us, the selection of notation is a matter of considerable importance, in order to obtain the greatest possible degree of clearness and brevity. In all cases when nothing is gained by the change, it is convenient to the reader that the notation should conform to the best established works already published. Professor Airy has in general used the notation of the *Mécanique Céleste*. He has, however, introduced a new notation, in order to express in an abbreviated manner the differentials of the quantities C , taken m times with regard to one major semiaxis, and n times with regard to the other, and multiplied respectively by the m th and n th powers of these semiaxes; these products occurring so frequently, that the adoption of a short symbol for them, $(m, n) C$, saves a great quantity of very repulsive labour.

Another abbreviation employed by Professor Airy respects the angles. In the development of the terms arising from the successive steps of the expansion of R , we obtain terms such as $e^2 \cos 2V$ and $e^3 \cos 3T$, multiplied by others, such as $\cos(11V - 11T)$; and by the resolution of such products we obtain the cosines of the sums and differences of these angles. But it appears that the sums

alone are useful. Hence it follows, that if we have, at a certain step of the process, $\cos(2V + 3T)$, its coefficient must be $e^2 e^3$, and this may be written $e^2 e^3 \cos(2 + 3)$ without fear of mistake; and this, when combined with such a term as $\cos(11V - 11T)$, will produce $e^2 e^3 \cos(13 - 8)$. This mode of writing and operating is also a great saving of labour; for V and T consist of the mean motions, with several constant terms added or subtracted.

The author states that he has paid great attention to ensuring the accuracy of the work; having gone through the calculation by two different methods, and compared the values thus obtained, both in several intermediate steps, and in the final results.

We regard this paper as the first specific improvement in the solar tables made by an Englishman since the time of Halley, as valuable from the care which the author has employed in the numerical calculations, as well as for the sagacity he has displayed in the detection of an inequality so small, and of so large period; and we recommend its insertion in the *Philosophical Transactions*.

(Signed)

W. WHEWELL.

J. W. LUBBOCK.

April 5, 1832.

DAVIES GILBERT, Esq., M.A. Vice-President, in the Chair.

Marshall Hall, M.D., Archibald John Stephens, Esq., Sir William Russell, Bart., M.D., Sir David Barry, Knt., M.D., and Charles Boileau Elliott, Esq., were elected Fellows of this Society.

The following Report, drawn up by Samuel Hunter Christie, Esq., M.A. F.R.S., and John Bostock, M.D. V.P.R.S., on Mr. Faraday's paper, read before the Royal Society on December 15, 1831, and entitled "*Experimental Researches in Electricity*," was read.

Report.

In the first section of this paper, the author considers the induction of electricity in motion.

Shortly after the discovery by Oersted of the influence of electricity in motion on a magnetic needle, it was almost simultaneously discovered by Arago, Davy, and Seebeck, that iron became magnetic by induction from the connecting wire of a voltaic battery, or the passage of an electric current; but though the effects at first observed were afterwards greatly increased by peculiar arrangements, induction was in all cases restricted to iron. Arago's beautiful experiments on magnetic needles vibrating within metallic rings, and on the mutual action of all metals and magnets, when either is in motion, are undoubtedly instances of a peculiar magnetic induction in other metals than iron; but the very doubtful experiment of Ampère can scarcely be adduced as one. The singular results obtained by MM. Marianini, De la Rive, and Von Beek, referred to by our author, are probably due to electric induction. But none of these

can be considered as having originated the discoveries described in the present paper, excepting so far as all new views originate in the contemplation of results previously obtained.

In this section of his paper the author shows that a peculiar state is induced in a copper wire which is in the immediate neighbourhood of another, through which an electric current passes, that is, which forms the connecting wire in a voltaic circuit. This state of the wire was manifested by its action on a magnetised needle, and by the induction of magnetism in steel wire submitted to its action.

Two copper wires, each more than 200 feet in length, were wound in the same direction round a large block of wood, the coils of the one being interposed between those of the other, and metallic contact everywhere prevented. The ends of one wire were connected with a galvanometer, and with the ends of the other, contact could be made or broken with a battery of one hundred and twenty pairs of plates. On the contact with the battery being made, the needle of the galvanometer was invariably impelled in one direction, and on the interruption of the contact, it was always impelled in the contrary. After the first impulse on the completion of the voltaic circuit, the needle resumed its natural position, no permanent deflection whatever occurring during the time that this circuit remained complete.

On substituting a helix of copper wire formed round a glass tube for the galvanometer; introducing a steel needle; making contact, as before, between the battery and the inducing wire; and then withdrawing the needle, previously to breaking the battery contact, it was found to be magnetised. If the contact was first made; a needle introduced in the tube; the contact broken; the needle on being withdrawn was found to be magnetised to the same degree nearly as the first, but the poles at the corresponding ends were of the contrary kind.

If the circuit between the wire under induction and the galvanometer was not complete when the contact with the battery was made, then no effect on the needle was observable either on completing or again breaking the first circuit. But the battery communication being *first* made, and *then* the wire under induction connected with the helix containing the needle, on interrupting the battery circuit, the needle was magnetised. These last facts, in a theoretical point of view, are most important: they prove that on completion of the voltaic circuit, the state of the wire under induction undergoes a double change, the one momentary, the other permanent so long as the voltaic circuit remains complete, and only exhibiting a momentary action on the interruption of that circuit.

From the experiments detailed in this section, the author concludes, that currents of voltaic electricity produce, by induction, currents (but which are only momentary) parallel to or tending to parallelism with the inducing currents; that the induced current, by the first action of the inducing current, is in the contrary direction to, and by its cessation in the same direction as, that of the inducing current.

The author next introduced iron into his arrangement, by which means a double induction took place, the iron itself becoming magnetic by induction, in the first instance, and electricity being induced in the copper wire from the magnetised iron, in the second. The effects were here of precisely the same character as before, but greatly increased. By this arrangement unequivocal evidence of electricity in the wire under induction was obtained; for not only was the needle in the galvanometer violently affected, but a minute spark could be perceived on using charcoal at the ends of that wire.

On dispensing altogether with the voltaic arrangement, and substituting for the electro-magnet a cylinder of soft iron, rendered magnetic by contact with two bar magnets, or a common cylindrical magnet of steel, similar results were still obtained. The arrangement and the effects were simply these: several helices of copper wire were formed, in the same direction, round a hollow cylinder of pasteboard, metallic contact being prevented between the contiguous coils: of these, either the *alternate ends* were united, to form *one* long helix, or *all* the corresponding ends to form a *compound* helix; and within the pasteboard cylinder, a cylinder of soft iron was introduced: on the ends of this cylinder being brought into contact with the poles of two bar magnets, united at the other ends so as to resemble a horse-shoe magnet, the needle of the galvanometer was impelled in one direction, and on the contact being broken, in the contrary. Similar effects were produced by simply introducing a cylindrical steel magnet into the hollow cylinder over which the copper wire was wound. The effects were strikingly increased, but were still of precisely the same character, when Knight's large compound magnet, belonging to the Royal Society, was substituted for the bar magnets. Here, the mere approximation to the magnet, of the compound helix, whether containing the cylinder of soft iron or not, was sufficient to impel the needle in one direction, and its recess from the magnet, to give a contrary impulse. But even here, the effects were purely impulsive, the needle invariably returning to its undisturbed direction, when the contact was continued.

As in the voltaic arrangement, a small voltaic apparatus, sufficient to deflect the needle of the galvanometer 30° or 40° , being introduced between the galvanometer and the helix under induction, produced no effect on the impulses given to the needle, on making and breaking contact of the iron cylinder with the magnet: nor did the power of this arrangement appear to be affected after making the contact or after breaking it.

Although all attempts to obtain chemical effects or a spark in this case failed, yet we agree with the author that these experiments prove the production of electricity by ordinary magnetism, and think the reasons which he adduces for its want of energy satisfactory*.

* Since this report was written, a brilliant electric spark has been obtained by Mr. Faraday and Mr. Christie with this magnet, by the very means which, at this time, failed, in consequence of two contacts not taking place at the same instant, on which circumstance the success of the experiment appears entirely to depend.

This discovery has therefore supplied the link in the chain of connexion between electricity and magnetism, which has been wanting since Oersted's discovery. That the electricity developed acts in a peculiar manner, so far from diminishing the interest attached to the discovery, adds greatly to its value.

After the detail of these perfectly original and highly interesting experiments, the author considers the peculiar electric state of the wire when subjected either to volta-electric or magneto-electric induction. This state he terms the electro-tonic state.

Unlike the induction from electricity of tension or the ordinary induction from a magnet, this state of the wire is not analogous to that of the inducing wire; for whatever may be the permanent state of the wire under induction while the voltaic circuit is complete, or the magnetic contact is unbroken, so long as either of these continues, there is no evidence of any change having taken place in it, and its change of state is only rendered manifest at the instant of interrupting the circuit or the contact, and at that of again renewing them; impulsive forces being brought into action at either instant, but in contrary directions in the two cases.

The author observes, that this peculiar condition shows no known electrical effects whilst it continues, nor has he yet been able to discover any peculiar powers possessed by matter whilst retained in this state; that no re-action is shown by attractive or repulsive powers; that no retarding or accelerating power is exerted upon electric currents passing through metal in the electro-tonic state, that is, the conducting power is not altered by it; that all metals take on this peculiar state; that the electro-tonic state is altogether the effect of the induction excited, and ceases with the inductive power; that this state appears to be *instantly* assumed, the force brought into action at the instant of its assumption being merely impulsive.

The author considers that the current of electricity which induces the electro-tonic state in a neighbouring wire, probably induces that state also in its own wire, and that this may be the case with fluids and all other conductors; and concludes that if it be so, it must influence voltaic decomposition and the transference of the elements to the poles. Should facts be found to accord with these views, we consider the author fully justified in his anticipations of the importance of his discovery as applicable to the decomposition of matter, and we certainly feel that the discovery could not have been made by any one more likely to decide this question, or more able to avail himself of a new principle of decomposition when discovered.

In the series of actions proceeding from the voltaic battery which this discovery exhibits to us, a very curious succession is observable. Volta-electricity passes along the connecting wire of the battery, electro-magnetism at right angles to it. By this means the cylinder of soft iron, within the helix into which the connecting wire is formed, becomes a magnet. If the poles of the magnet be joined by an iron bar, ordinary magnetism passes along this bar, but magneto-electricity is induced at right angles to it in a helix wound round it. And again, magneto-electricity is propelled along the wire, and magnetism

is induced in a steel bar at right angles. This bar may again induce magneto-electricity in a wire at right angles to it, by which another bar may become magnetic; and so on, showing a repetition of similar powers successively brought into action, but their efficiency at each step greatly diminished.

The effects hitherto described were due to a momentary action: in order to obtain continuous action the author applied the principle of circular motion. For this purpose a thick copper disc was made to revolve near the magnet, so that a portion near its edge passed between the ends of two bars of iron which concentrated and approximated the poles. The edge and a portion round the centre of the disc were well amalgamated: an amalgamated conductor was applied to the edge of the disc near the poles, and with this, one end of the wire of the galvanometer was connected, the other end being connected with the centre of the disc. While the disc revolved, the needle of the galvanometer was permanently deflected at least 45° in one direction; and when the motion of the disc was reversed, the permanent deflection was in the opposite direction.

When the disc revolved horizontally in the direction of the sun's daily motion, the unmarked pole being beneath the disc and the marked pole above, it appeared, by the indications of the galvanometer, that positive electricity was collected at the edge of the disc nearest to the poles: if the marked pole was below and the unmarked pole above, then negative electricity was collected at that part of the disc: and if in either case the direction of the motion was reversed, the nature of the electricity collected at the same place was also reversed.

The experiment being made in a still more simple form, by passing a plate of copper longitudinally between the poles of the magnet, it appeared that positive electricity was collected on one edge of the plate, and negative on the opposite; and if the plate was passed in the contrary direction, then the electricities on the edges were reversed.

When a wire was passed laterally between the poles, similar results were obtained.

The law according to which the electricity excited depends upon the pole of the magnet near which a wire moves, and the direction of its motion, although not so expressed by the author, appears to be this: Let the wire revolve parallel to itself about a bar magnet, so that its centre coincides with any curve;—for example, (in order to mark more readily the points where the direction of the current of electricity changes,) with an ellipse, the major axis of which coincides with the axis of the magnet, and the minor axis passes through its centre; let the wire be inclined at any angle to the plane of the ellipse, which in the first instance we will suppose to be horizontal, and that the marked end of the magnet is pointing north; and let the wire move parallel to itself in the direction of the sun's daily motion; then while the wire revolves from the *western* extremity of the axis minor round the *marked* pole to the *eastern* extremity, the electric current will be from the end of the wire *below* to the end *above* the orbit:

while it is revolving from the *eastern* extremity round the *unmarked* pole to the *western* extremity of the axis minor, the current of electricity will be from the upper to the lower end of the wire; and whatever position the plane in which the wire revolves may take by revolving about the axis of the magnet, or whatever may be the position of this axis, still the current of electricity will be from the end of the wire in the same position, relatively to the plane of revolution, as before. If the direction of the motion be reversed, the direction of the current will likewise be reversed.

It would follow from this, that if two wires parallel to each other, on opposite sides of a bar magnet, and perpendicular to its axis, be moved along the sides of the magnet in the same direction, the currents of electricity in them will be in opposite directions; and hence we may draw this important conclusion,—that there must be some internal arrangement in a magnet, whether of currents or of particles, which renders the same absolute motion, a motion in contrary directions relatively to such arrangement on the opposite sides of the magnet.

From all these experiments the author concludes, that when a piece of metal (and the same may be true of all conducting matter,) is passed either before a single pole, or between the opposite poles of a magnet, electric currents are produced across the metal, transverse to the direction of motion; and which therefore in M. Arago's experiments approximate towards the direction of radii. Assuming the existence of these currents, he satisfactorily accounts for the phenomena observed in these experiments and in those by Mr. Babbage and Sir John Herschel. Thus, the disc revolving in the direction of the sun's daily motion beneath the marked pole of a magnet, currents of positive electricity set from the central part towards the circumference near the pole, and the action of these currents is to move the pole also in the direction of the sun's motion; so that the magnet, if at liberty to revolve, will move in the same direction as the disc.

Electric currents similar to those produced by passing copper between the magnetic poles, were produced by iron, zinc, tin, lead, mercury, and all the metals tried. The carbon deposited in the coal-gas retorts also produced the current, but ordinary charcoal did not; nor could any sensible effects be produced with brine, sulphuric acid, or saline solutions. Although the author succeeded in obtaining a continuous current of electricity by means of the revolving disc, yet he was not able, by this means, to produce any sensation upon the tongue, to heat fine platina wire, to produce a spark with charcoal, to convulse the limbs of a frog, or to produce any chemical effects. That he should have failed in obtaining these most striking effects of electricity, we attribute to the feebleness of the electricity excited, and feel assured that by adopting means greatly to increase the intensity, all these effects will result from the electricity derived from ordinary magnetism.

The facts contained in this paper of Mr. Faraday's, and the con-

clusions which he draws from them are so important, that we feel we should not have done justice to the communication, had we not given an abstract of the whole, at the same time that we stated our opinion of its value. Had the author's discovery consisted alone of the simple fact, that steel may be magnetised by a distant magnet, in a manner similar to that employed with the voltaic battery, we should have considered it of the highest importance in the inquiry concerning the connexion between magnetism and electricity; but when we see permanent effects which, hitherto, have only been derived from electricity, now derived from the common magnet, by calling in the aid of motion, showing clearly that electricity can thus be excited; and find that the laws which govern the phenomena are established, we cannot but entertain hopes that a door has been opened through which may at length be discovered the precise distinction between two agents which in many respects so greatly resemble each other in their effects and in their laws of acting. Such being our opinion of the results obtained by Mr. Faraday, we can have no hesitation in recommending most strongly the publication of his paper in the Transactions of the Royal Society.

(Signed)

S. H. CHRISTIE.
J. BOSTOCK.

Dr. Davy's Paper on the Torpedo, was then read in continuation.

April 12, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.
President, in the Chair.

The reading of Dr. Davy's Paper, entitled, "An Account of some experiments and observations on the Torpedo," was resumed and concluded.

The late Sir Humphry Davy gave an account, in a paper published in the Philosophical Transactions for 1829, of some experiments which he made on the Torpedo, with the view of ascertaining how far its electricity is analogous to that of the voltaic, or other galvanic batteries; but the results he obtained were altogether of a negative kind. He was prevented by the declining state of his health from prosecuting this inquiry, which he was still ardently bent upon completing, and which he requested his brother would carry on after his death. The author, accordingly, when at Malta, being in a favourable situation for obtaining living torpedos, made the series of experiments which are related in the present paper. They entirely confirm those of Mr. Walsh made in 1772, and which established the resemblance of the agency exerted by this fish to common electricity; and they also prove that, like voltaic electricity, it has the power of giving magnetic polarity to steel, of deflecting the magnetic needle, and also of effecting certain chemical changes in fluids subjected to its action. Needles perfectly free from magnetism were introduced within a spiral coil of copper wire, containing about 180 convolutions; the whole coil being an inch and a half long and one

tenth of an inch in diameter, weighing only four grains and a half, and being contained in a glass tube just large enough to receive it. On the electric discharges from a vigorous torpedo being made to pass through the wire during a few minutes, the needles were rendered strongly magnetic. The same influence transmitted through the wires of the multiplier produced very decided deflexion of the needle; the under surface of the electrical organ of the torpedo corresponding in its effect to the zinc plate of the simple voltaic circle, and the upper surface corresponding to the copper plate. No effect of ignition could be perceived when the discharge from the torpedo was made to pass through a silver wire one thousandth of an inch in diameter: nor could unequivocal evidence be obtained of the production of sparks on interrupting the circuit; the slight luminous appearances which occurred being probably of the same kind as those often exhibited by sea water when agitated. A small gold chain, however, composed of sixty double links, was found to be capable of transmitting the shock; a fact which seems to show that air is not impermeable to the electricity of the torpedo. When fine silver wires, interrupted by a solution of common salt, were placed in the circuit, minute bubbles of air collected round the point communicating with the under side of the torpedo, but none at the other point. When gold wires, instead of the silver ones, were used, gas was evolved from each of the extremities; but in greatest quantity, and in smaller bubbles, from the lower, than from the upper wire. With a strong solution of nitrate of silver, the point of the lower gold wire became black, and only two or three bubbles arose from it; the point of the upper gold wire remaining bright, and being surrounded with many bubbles. Similar, but less distinct, results were obtained by employing a strong solution of superacetate of lead.

The remainder of the paper is occupied with a detailed account of the anatomical structure of the electrical organs of the torpedo, and of the muscles that surround them. The texture of the columnar portions of those organs appears to be homogeneous, with the exception of a few fibres, probably branches of nerves, which pass into them. A large quantity of water, separable by evaporation, enters into their composition: and they undergo spontaneous changes more slowly than the muscles. They are incapable of contraction by any of the ordinary stimuli, and even that of an electric shock from a voltaic battery, applied either to the organs themselves or to the nerves which supply them. Hence the conclusion is drawn that these organs are not muscular, but that their columns are formed by tendinous and nervous fibres, distended by a thin gelatinous fluid.

The anatomical account is concluded by a description of the origin, course, and distribution of the nerves belonging to the electrical organs. The author found that the gastric nerves are derived from these; and hazards the conjecture that superfluous electricity may, when not required for the defence of the animal, be directed to the stomach, so as to promote digestion: in corroboration of which he cites the instance of a torpedo which, when living, had

been frequently excited to give shocks, and in whom a small fish found in its stomach after death, appeared to be totally undigested. The secretion of mucus was also either suppressed or considerably diminished. From the circumstance that the branchiæ are supplied with twigs of the electrical nerves, the author conceives there may be some connexion between the electrical and the respiratory functions; and that the evolved electricity may be employed in decomposing water, and in thus supplying the system with air, in situations where the animal has not access to that of the atmosphere. The author considers the mucous system of the torpedo as performing important offices in its economy, in consequence of its connexions with the electrical nerves. Contrary to the statement of Mr. Hunter, he finds that the electrical organs are very scantily supplied with blood-vessels. He concludes by some remarks on the peculiar characters of the electricity of the Torpedo, the purposes it appears to serve, and the varieties exhibited by different individuals, according to the age, the sex, and other circumstances.

The Meetings of the Society were then adjourned over Easter to the third of May.

May 3, 1832.

JOHN BOSTOCK, M.D. Vice President, in the Chair.

The following Report, drawn up by the Rev. William Whewell, M.A. F.R.S., the Rev. George Peacock, M.A. F.R.S., and the Rev. Henry Coddington, M.A. F.R.S., on Mr. Lubbock's Paper, read before the Royal Society Feb. 9, 1832, and entitled, "Researches in Physical Astronomy," was read.

Report.

The method of the variation of parameters as applied to the investigation of the perturbations of the solar system has been successively developed in modern times. This method gives the variations of the elements of the elliptical orbit in terms of the differentials of a certain function R of these elements, and of the disturbing forces. Euler, Lagrange (1783), Lagrange and Laplace (1808) obtained the formulæ for $d\alpha, de, d\varpi, dp, dq$ where $p = \tan \phi \sin \theta, q = \tan \phi \cos \theta$. Poisson first gave the expression for $d\varepsilon$. Pontécoulant, p. 330, has introduced $d\iota$ and $d\nu$ instead of dp and dq ; but those developments gave expressions neglecting the square of the disturbing force. Mr. Lubbock has published (in a Paper in the Phil. Trans. April 1830,) expressions which include the effect of any power of the disturbing force. This method has been principally applied to the secular inequalities; but it is susceptible of being applied with no less strictness to periodical inequalities, all of which may be represented by certain changes in the elements of the elliptical orbit.

But the same problems may also be approximately solved directly; for we obtain a differential equation involving the radius vector and the time. In this equation there occurs the same func-

tion R of which we have already spoken; and this function is expanded according to terms involving cosines of the mean motions of the disturbing and disturbed planet, and cosines of the difference of certain multiples of these motions. This expression has been treated of by various authors, and among others Mr. Lubbock has himself (in memoirs read May 19 and June 9, 1831,) given the expansion of R in a form suited to his present object.

The coefficients of the terms in this expansion are arranged, as usual, according to the order of the excentricities, their powers and products, and to the power of the \sin^2 of half the inclination. These coefficients involve also certain quantities $b_{n,i}$ where n and i have a variety of values; and these quantities depend on the ratio of the mean distances of the disturbing and disturbed bodies from the sun.

Solving the differential equation which involves r , by the equating of coefficients, Mr. Lubbock finds a value for the reciprocal of r in such terms as have been mentioned. By certain algebraical transformations of the fractional coefficients in which i occurs, (and by certain equations of condition between b_{3i-1} , $b_{3,i}$, b_{3i+1} , and between similar quantities,) the expression for the reciprocal of r is transformed and reduced, the arcs remaining as they were.

But by the properties of the ellipse, the reciprocal of r is equal to a series of terms involving the excentricities, and involving also cosines of the mean anomaly and its multiples: and hence the variation of this reciprocal is equal to a similar series, involving sines and cosines of such arcs, and involving also the variations of the elliptic elements. By substituting the variations of the elliptic elements given by the formulæ above mentioned, when we put for R its expansion, we have a certain series of sines and cosines with their coefficients multiplied into certain other sines of the same kind.

It is found that the sines and cosines thus multiplied produce, by trigonometrical transformations, arcs identical with those which were found in the value of the reciprocal of r obtained by the former method; and the coefficients are also found to be identical with those resulting from the former transformations and reductions.

We have not thought it necessary to verify the somewhat complex reductions by which Mr. Lubbock has shown the identity of the results obtained by these two methods. The mode of proceeding is perfectly satisfactory, and the truth of the conclusion might have been foreseen. The reductions, however, by which identity was to be exhibited were by no means obvious: and we conceive it not unlikely that the development of them may sometimes be of use in enabling us to judge which of the two methods of solution may be applied with most convenience in particular cases.

We are of opinion that this Paper is well worthy of being printed in our Transactions.

(Signed)

W. WHEWELL.

GEO. PEACOCK.

H. CODDINGTON.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1831-1832.

No. 10.

May 3, 1832. (Continued.)

JOHN BOSTOCK, M.D. Vice President, in the Chair.

A Paper was read, entitled, "An Account of certain new Facts and Observations on the Production of Steam," by Jacob Perkins, Esq. Communicated by Ralph Watson, Esq. F.R.S.

Having observed that water on the surface of melted iron was very slowly affected by the heat, although it exploded violently when the same fused metal was dropped into it, the author made a series of experiments on the time required for the evaporation of the same quantity of water successively poured into a massive iron cup, at first raised to a white heat, and then gradually cooled by the addition and evaporation of the water. The first measures of water were longer in being evaporated than those subsequently added, in consequence of the reduction in the temperature of the iron, until this temperature reached what the author calls the *evaporating point*, when the water was suddenly thrown off in a dense cloud of steam. Below this temperature, the time required for the complete evaporation of the same measure of water became longer in proportion as the iron was cooler, until it fell below the boiling point. The author accounts for these results from the circumstance that when the metal is at the higher temperatures, the water placed on its surface is removed from contact with it by a stratum of interposed steam. From these and other experiments, he is led to infer the necessity of keeping water in close and constant contact with the heated metal in which it is contained, in order to obtain from it, in the shortest time, the greatest quantity of steam.

The reading of a Paper, entitled, "On certain Irregularities in the Magnetic Needle, produced by partial warmth, and the relations which appear to subsist between terrestrial Magnetism and the geological Structure and thermo-electrical Currents of the Earth," by Robert Were Fox, Esq. Communicated by Davies Gilbert, Esq. V.P.R.S.—was commenced.

May 10, 1832.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer,
in the Chair.

The reading of Mr. Fox's Paper was resumed and concluded.

The author begins by an account of some experiments which he instituted with a view to discover the cause of the irregularities in the indications of the intensity of terrestrial magnetism given by the vibrating magnetic needle. By inclosing the needle in a box surrounded with water at different temperatures, the number of the vibrations did not appear to be affected by these differences of temperature when the heat was applied equally on all sides ; but when partially applied, irregular oscillations took place, apparently from the currents of air set in motion by the inequalities of its temperature. Hence the author recommends that for delicate experiments the magnetic needle should be contained in a box of wood, or other imperfect conductor of heat ; or, for still greater security, that it should be adjusted in a glass vessel exhausted of air. For experiments on magnetic intensity at sea, he recommends placing two magnets at some distance from the needle, in the line of its magnetic meridian, and surrounded with water, in order to preserve a uniformity of temperature. For increasing the action of terrestrial magnetism, he suggests the employment of a bar or cylinder of wrought iron, placed perpendicularly, or in the line of the dip, at right angles to the meridian, so as to repel the north pole of the needle : and also surrounded with water.

The experiments made with an apparatus of this kind in some of the deep mines in Cornwall, did not lead to the conclusion that there is any increase of magnetic intensity at the depth of 1000 or 1200 feet below the level of the sea ; but if any thing, rather the reverse ; but, on the whole, the discrepancy in the results was so great, that no dependence can be placed on them as establishing a general fact of this importance.

It appeared also to the author that the direction of electrical currents under the earth's surface is greatly diversified ; although, when taken collectively, the probability is that the tendency of the positive currents is from east to west.

The author then proceeds to state the results of his experiments on the thermo-electricity of rocks. He found that compact slate was an excellent conductor of electricity ; and that the heated end gave indications of positive electricity. Granite, on the contrary, at a bright red heat, was almost incapable of conducting electricity, but when vitrified became nearly a perfect conductor, owing probably to the destruction of its crystalline structure. In general the end most heated was negative, and the same was the case with porphyritic feldspar. Greenstone and serpentine, which also occur in frequent alternations in Cornwall, in like manner differ in their electrical properties ; the former giving out positive, and the latter negative electricity at their most heated parts. Many anomalies, however, occurred in these properties, the results being frequently reversed without any obvious cause.

On the hypothesis of the existence of a very elevated temperature in the interior of the globe, it would necessarily follow from the preceding experiments that electrical currents would be produced from this cause, taking frequently different, and even opposite di-

rections, and exerting an important influence on all the phenomena of terrestrial magnetism, both such as are general, and also such as appear to be local anomalies. The later researches of the author have satisfied him that the directions of these currents are probably much influenced by the geological structure of the globe; which would in most cases tend to give them more or less obliquity to the parallels of latitude. The author ascribes the diurnal changes in the direction and intensity of terrestrial magnetism to the successive action of the sun on the different portions of the surface of the globe. With reference to the causes that have determined the juxtaposition and arrangement of rocks in the interior of the earth, the author examines their comparative expansibility by heat. Granite, porphyritic feldspar, and clay-slate expanded from one-50th to one-77th by a red heat; while the expansion of serpentine, by the same heat, could not be rendered sensible. He concludes by calling in question the theory which ascribes the spheroidal form of the earth to its having been once a mass of plastic matter in igneous fusion or in aqueous solution.

May 17, 1832.

The Rev. WILLIAM BUCKLAND, D.D. Vice President,
in the Chair.

The reading of a Paper, entitled, "On Harriot's Astronomical Observations contained in his unpublished Manuscripts belonging to the Earl of Egremont," by Stephen Peter Rigaud, Esq. M.A. F.R.S. Savilian Professor of Astronomy in the University of Oxford,—was commenced.

May 24, 1832.

DAVIES GILBERT, Esq. D.C.L. Vice President, in the Chair.

The reading of Professor Rigaud's Paper was resumed and concluded.

In the Memoirs of the Royal and Imperial Academy of Brussels, for the year 1788, the Baron de Zach published a paper on the planet Uranus, in a note to which he states that, in the summer of 1784, he found in the library of Lord Egremont at Petworth, some old manuscripts of the celebrated Thomas Harriot, which he alleges afforded proofs that he had observed the solar spots, and the satellites of Jupiter before Galileo. In the Berlin Ephemeris for 1788, Baron Zach gave a full account of his alleged discovery, drawn up from Harriot's papers; an English translation of which was circulated in this country, and has been perpetuated by its being inserted in Dr. Hutton's Mathematical Dictionary. The author, having been entrusted by Lord Egremont with Harriot's original papers, has examined them with every attention he could apply to the subject, and gives in the present memoir the result of his inquiry.

The observations of Harriot on the spots on the sun, fill seventy-four half-sheets of foolscap, the first being dated December 8, 1610.

These papers are in good preservation : the writing is clear, and the drawings well-defined. Baron Zach says, that "he compared the corresponding ones with those observed by Galileo, and found betwixt them an exact agreement." This, the author shows, is very far from being the case, and he also brings evidence to prove that the discovery of the spots on the sun was made by Galileo at latest in the summer of the year 1610, and very probably in or before the month of July. He allows, however, that Harriot's observation in December of the same year, was the result of his own spontaneous curiosity.

The first observation made by Harriot of the satellites of Jupiter, has for date the 17th of October 1610. Those that follow, extend to the 26th of February 1612: they are clearly written out on thirteen half-sheets of foolscap. But, even by the statement of Baron Zach, Galileo discovered them on the 7th of January 1610; that is, nearly eight months before Harriot.

The author has detected many other material inaccuracies in the account given to the world by Baron Zach of Harriot's observations. He concludes, however, by observing that Harriot ought not to be deprived of the credit which is justly due to him, because a greater share has by some persons been claimed for him than he is justly entitled to. He himself made no pretensions to priority in the discoveries in question.

May 31, 1832.

DAVIES GILBERT, Esq. D.C.L. Vice President, in the Chair.

The reading of a Paper, entitled, "On the Correction of a Pendulum for the reduction to a vacuum, together with Remarks on some Anomalies observed in Pendulum Experiments," by Francis Baily, Esq. F.R.S.,—was commenced.

June 7, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.

President, in the Chair.

Lord Henry John Spencer Churchill; the Hon. George Charles Agar, M.A.; John Disney, Esq.; James Clark, M.D.; James Hope, M.D.; the Venerable George Glover, M.A.; Michael Thomas Sadler, Esq. M.P.; Lieut. William Samuel Stratford, R.N.; James David Forbes, Esq., and Howard Elphinstone, Esq. M.A., were elected Fellows of the Society. Baron Damoiseau of Paris, Professor de Blainville of Paris, Professor Carlini of Milan, Professor Cauchy of Paris, and Professor Tiedemann of Heidelberg, were elected Foreign Members of the Society.

The reading of Mr. Baily's Paper on the Pendulum, was resumed and concluded.

The author observes, that in all the experiments hitherto made with the pendulum, a very important correction, depending on the influence of the circumambient air, has been omitted; and that the phi-

losophical world is indebted to M. Bessel for having first drawn the attention of the public more immediately to this subject. For, although Newton evidently suspected that such an influence existed, and although the subject had been since fully discussed by the Chevalier du Buat, nearly 50 years ago, yet it does not appear that any of the distinguished individuals, employed by the different Governments in making experiments on the pendulum in more recent times, have had any notion that the effect of the air, on the moving body, was any other than that depending on its density ; and consequently varying in amount according to the specific gravity of the metal of which the pendulum might be composed. But M. Bessel has shown that a quantity of air is also set in motion by the pendulum (varying according to its form and construction), and thus a *compound pendulum* is in all cases produced, the specific gravity of which will be much less than that of the metal itself. M. Bessel's principal experiments for establishing the accuracy of this principle, were made with two spheres, about two inches in diameter, differing from each other very considerably in specific gravity, one being of brass, and the other of ivory, and each suspended by a fine steel wire. The author of the present paper, however, pursued another and a very different course for obtaining the same end : namely, by swinging the same pendulum first in free air, and afterwards in a highly rarified medium, nearly approaching to a vacuum. From the difference in the results, he deduces a factor (denoted by n), by which the old, and hitherto received, correction must be multiplied in order to obtain the new and more accurate correction indicated by M. Bessel ; and which, in the case of the two spheres above mentioned, is found by that author to be equal to 1.95.

But Mr. Baily, instead of confining himself to spheres of this size, and composed of these two substances only, has extended his inquiries to pendulums of various magnitudes, substances and forms. His first recorded experiment is on Borda's platina sphere, the diameter of which is 1.44 inches ; and he found that the old correction must in this case be multiplied by 1.88 in order to obtain the true and accurate correction ; or, in other words, that the old correction was but little more than half what it ought to be. The author then tried three other spheres of precisely the same diameter, but differing considerably in specific gravity : namely, lead, brass, and ivory, all of which gave nearly the same result ; the mean of the whole being $n = 1.86$. He next proceeded to spheres of the size used by M. Bessel, made of three different substances, viz. lead, brass, and ivory. These gave a result (agreeing very well with each other,) somewhat smaller than the former ; the mean of the whole being $n = 1.75$: thus showing that the factor for the additional correction is due to the form and magnitude of the moving body, and not to its weight or specific gravity. This last value, as the author observes, differs from that deduced by M. Bessel as above mentioned ; but the cause of the discordance does not appear.

The author then shows the effect produced on cylinders of various kinds, both solid and hollow, and suspended in different ways,—on

lenses, on cylindrical rods, on bars, on tubes, on convertible pendulums, and on several clock pendulums, amounting to upwards of 40 in number. The results of these experiments give in each case a different value for the factor n ; and which appears to depend on the extent of surface, in proportion to the bulk of the body exposed to the direct action of the air when in motion: further experiments, however, are requisite to establish this point in a satisfactory manner*. But, in the author's opinion, enough is shown to indicate the necessity and propriety of a revision and correction of all the experiments hitherto made with the pendulum, either for the determination of its absolute length, or for ascertaining the true figure of the earth; and that for this purpose, the true correction must be found from actual experiment in each particular case; since, with very few exceptions, it cannot be determined by any mathematical deduction.

Mr. Bailly then proceeds to point out some singular discordances arising from the knife-edge mode of suspending the pendulum, where the *same* knife-edge and the *same* agate planes are employed. From which he is led to infer that the pendulum furnished with a knife-edge and agate planes, as at present constructed, is a very inadequate instrument for the delicate purposes for which it was originally intended; and that a more rigid examination of that part of the instrument is requisite, before we can rely with confidence on the accuracy of the results obtained by it.

Some anomalies are then pointed out in the magnitude of the arc of vibration, and some remarks offered on the supposed inadequacy of the usual formula for determining the correction for the arc; but the author considers it desirable that further experiments should be made for the more accurate determination of this point.

In conclusion, the author expresses a doubt of the rigid accuracy of the length of the seconds pendulum, as deduced from the recent experiments of Captain Sabine.

To the whole are appended tables exhibiting the details of all the experiments made by the author, and the corresponding results.

A Paper was read, entitled, "Researches in Physical Astronomy," by John William Lubbock, Esq. V.P. and Treas. R.S.

The present paper contains some further developments of the theory of the moon, which are given at length, in order to save the trouble of the calculator, and to avoid the danger of mistake. The author remarks, that while it seems desirable, on the one hand, to introduce into the science of physical astronomy a greater degree of uniformity, by bringing to perfection a theory of the moon founded on the integration of the equations employed in the planetary theory, it

* Since this paper was read, the author has made a number of additional experiments on various other pendulums, which, by permission of the Council, will form part of the original paper; and from which he is led to infer that, in the case of spheres, cylinders, and other bodies suspended by rods of different diameters, the value of the factor depends not only on the body appended to such rod, but that the rod itself has a considerable influence on the result, except it be a very fine wire; when its effect becomes merged in that of the appended body.

is also no less important, on the other hand, to complete, in the latter, the method hitherto applied solely to the periodic inequalities. Hitherto those terms in the disturbing function which give rise to the secular inequalities, have been detached, and the stability of the system has been inferred by means of the integration of certain equations, which are linear when the higher powers of the eccentricities are neglected; and from considerations founded on the variation of the elliptic constants. But the author thinks that the stability of the system may be inferred also from the expressions which result at once from the direct integration of the differential equations. The theory, he states, may be extended, without any analytical difficulty, to any power of the disturbing force, or of the eccentricities, admitting the convergence of the series; nor does it seem to be limited by the circumstance of the planet's moving in the same direction.

A Paper was also read, entitled, "On the Nervous System of the *Sphinx Ligustri* (Linn.), and on the Changes which it undergoes during a part of the Metamorphoses of the Insect," by George Newport, Esq. Communicated by Peter Mark Roget, M.D. Sec. R.S.

The author gives a minute anatomical description, accompanied by drawings, of the development and arrangement of the nerves of the *Sphinx Ligustri*, and the successive changes they undergo during the last stage of the larva, and the earlier stages of the pupa state. As this insect, in passing from its larva to its perfect state, remains for several months in a torpid condition, it affords a better opportunity of minutely following these changes, and of ascertaining in what manner they are effected, than most other insects; and the great comparative size of this species renders the investigation still more easy.

While in its larva state, this insect frequently changes its skin: it enlarges rapidly in size after each operation, and the nervous system undergoes a corresponding development. The author minutely describes the longitudinal series of ganglia, which extend the whole length of the animal. He remarks that the eleventh or terminal ganglion is distinctly bilobate, a form which, as suggested to him by Dr. Grant, is probably acquired by the consolidation of two ganglia which had been separate at an earlier period of development. A detailed account is then given of the nerves proceeding from these several ganglia.

During the change from the state of larva to that of the perfect insect, the number of the ganglia is found to diminish in consequence of the approximation and conjunction of adjacent ganglia; and the nervous cords which connect them are generally much shortened. A nerve is described which, from the mode of its distribution to the stomach, intestinal canal, and dorsal vessel, presents a remarkable analogy to the *pur vagum*, or pneumogastric nerve of vertebrated animals; so that the author considers it probable that its functions are somewhat similar to this nerve; as has, indeed, been already conjectured by Straus-Dürckheim. Another division of nerves exist, which, from the principal branches derived from each abdominal plexus being always distributed among the tracheæ, near the spiracles, are perhaps analogous to the sympathetic system of nerves of the higher classes of animals.

When on the point of becoming a pupa, the nervous lobes above the œsophagus are found to be considerably enlarged, and to have assumed more of the appearance of a cerebral mass; while, at the same time, the nervous cords descending from them are shortened and thickened. The ganglia are brought nearer together, and their intervening cords lie between them in an irregular manner, the ganglia themselves being retained in their proper places in the segments by the nerves running transversely from them. The nerves of the antennæ are enlarged, and the optic nerves are become much thicker and shorter than before. There is a remarkable enlargement of the thoracic nerves, particularly of those sent to the wings; and those belonging to the posterior pair of legs are curiously convoluted within the thorax, preparatory to their being uncoiled at the instant of the change being made to the pupa state.

These changes are followed minutely through several stages of development. The author expects to be able to lay before the Society, in a subsequent paper, the results of his investigation of the remaining stages, and to offer some observations upon the manner in which these changes are effected.

The Society then adjourned over Whitsun Week to the 21st of June.

June 21, 1832.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.
President, in the Chair.

Papers were read, bearing the following titles:

1. "An Account of the magnetical Experiments made on the Western Coast of Africa in 1830 and 1831," by Commander Edward Belcher of H.M.S. Etna. Communicated by the Rev. George Fisher, M.A. F.R.S., through Captain Beaufort, R.N. F.R.S.

The object of the inquiry specified in this paper, and of which the results are given in a tabular form, was to determine the relative horizontal intensities of terrestrial magnetism on the different parts of the coast of Africa which the author has been lately employed in surveying. The experiments were made with four needles constructed by Dollond on the model of those of Professor Hansteen; and the permanence of their magnetism during the voyage was verified by a comparison of trials made in England before and since the voyage. Errors arising from local causes of irregularity were guarded against by varying the places of observation at each station, and taking mean results.

2. "On the Use of a substance called the *False Tongue* in Foals," by Professor Sewell, of the Royal Veterinary College. Communicated by Sir Charles Bell, F.R.S.

The substance called the *false tongue*, which is thrown out from the mouth of the foal, either at the period of birth, or shortly before it, and to which various whimsical uses and virtues have been assigned, is conceived by the author to be requisite in this animal for the action of sucking, in consequence of its not respiring through

the mouth, but altogether through the nasal passages : an instinctive feeling prompting it to supply the loss of that substance by sucking the teat of the mother. Dr. Prout, who analysed a portion of this substance at the request of the author, finds it to be composed principally of coagulated albumen slightly modified. The author regards it as a secretion from the tongue of the foal.

3. "Journal of the Weather, kept at High Wycombe during the year 1831, with monthly Observations," by James G. Tatem, Esq. Communicated by William Allen, Esq. F.R.S.

These tables exhibit the greatest elevations and depressions of the barometer and thermometer for the year 1831, together with the means of the observations, which were made at 8 A.M., 3 P.M., and 10 P.M. ; the extremes of cold being given by a self-registering thermometer. The quantity of rain was measured every morning at 8 o'clock. The course of the wind is noted, and remarks subjoined, showing the results of a comparison with former years.

4. "Physical and Geological observations on the Lake of Oo near Bagneres de la Chou, in the year 1831," by M. Nerée Boubée, Professor of Geology at Paris. Communicated by P. M. Roget, M.D. Sec. R.S.

The author ascertained that the bottom of the lake, which is 230 French feet in depth, forms a level plane of great extent, and is covered with a stratum of mud composed of fine micaceous sand of a blue colour. The temperature of the bottom of the lake was 7° of the centigrade scale, at the middle 9°, at the surface 11°; that of the air varying from 14° to 15°. There was no indication of any current on the surface. A cascade 954 feet in height falls into the lake, carrying down the detritus of the surrounding rocks.

5. "Observations on the anatomy and habits of Marine Testaceous Mollusca, illustrative of their mode of feeding," by Edward Osler, Esq. Communicated by L. W. Dillwyn, Esq. F.R.S.

The author observes that in studying the physiology of the Mollusca, more satisfactory results may generally be obtained by tracing the organization connected with each important function, through different families, than by complete dissections of individual species ; and, by thus connecting the study of function with that of structure, the zoologist is led to more certain inferences relating to those habits, the knowledge of which the pelagic character of the animal, and the difficulty of direct observation, would otherwise have rendered unattainable. The present paper is devoted to the anatomical investigation of the organs by which the food is received into the bodies of certain Mollusca. The herbivorous Mollusca which the author has examined have three modes of feeding. Some, as the *Trochus crassus*, browse with opposite horizontal jaws : others, as the *Turbo littoreus*, rasp their food with an armed tongue stretched over an elastic and moveable support : while others again, as the *Patella vulgata*, gorge it entire. The author enters into a minute anatomical description of the organs of manducation and deglutition, and also of that part of the nervous system situated in the neighbourhood of these organs, in each of these respective Mollusca,—illustrated by numerous draw-

ings. He gives in each case a particular account of the mode of dissection, with a view to direct succeeding observers to obtain a distinct view of the parts he describes, and to verify the conclusions he has himself obtained.

He next notices a considerable modification in the structure of these organs which is presented in the *Chiton*. In this animal he finds a pair of simple lateral jaws, rather membranous than cartilaginous. Another variety of structure adapted for gorging food is met with in the *Patella mammillaris*, where there is simply a very muscular mouth and pharynx, but neither cartilage, tongue, nor hard part of any kind.

The apparatus by which the *Buccinum Lapillus* drills through shells in order to obtain its food, and the process it employs for that purpose, are next investigated; and that of the *Buccinum undatum* is particularly examined with the same view, the structure of the latter being very fully displayed.

The author hopes to be enabled to pursue these inquiries with respect to other tribes of Mollusca at some future period.

6. "On the Mammary Glands of the *Ornithorhynchus paradoxus*," by Richard Owen, Esq. Communicated by J. H. Green, Esq. F.R.S.

The author premises a history of the different opinions that have been entertained with respect to the anatomy and economy of this singular animal, which was first described and figured by Dr. Shaw in the year 1792. The name of *Ornithorhynchus*, which it at present bears, was given to it by Blumenbach; and some account of the structure of the head and beak was given in the Philosophical Transactions by Sir Everard Home in 1800; and in a subsequent paper he states his opinion that this animal differs considerably from the true mammalia in its mode of generation, an opinion which was adopted by Professor Geoffroy St. Hilaire, who accordingly placed it, together with the *Echidna*, in a separate order designated by the term *Monotrèmes*. He afterwards formed this group into a distinct class of animals, intermediate to mammalia, birds, and reptiles. Oken and De Blainville, on the other hand, condemned this separation; and maintained that the monotremata should be ranked among mammalia, and as being closely allied to the marsupialia; and hazarded the conjecture that they possessed mammary glands, which they expected would ere long be discovered. Professor Meckel has since described these glands as being largely developed in the female *Ornithorhynchus*. He considers this animal, however, in the mode of its generation, as making a still nearer approach to birds and reptiles, than the marsupial tribe. He was unable to inject these glands in consequence of the contracted state of the ducts arising from the action of the spirit in which the specimen was preserved, and from their being filled with a concrete matter. Geoffroy St. Hilaire, in a subsequent memoir, persists in denying that these bodies possess the characters of mammary glands; but regards them as a collection, not of acini, but of cæca, having only two excretory orifices, and presenting no trace of nipples.

The author of the present memoir, having examined with great

care the specimens of the female *Ornithorhynchus* preserved in the Museum of the Royal College of Surgeons, found the structure to correspond very exactly with the account given by Meckel; and, moreover, succeeded in injecting the ducts of these glands with mercury. He further notices the differences of development occurring in five different specimens: the size of these glands having an obvious and direct relation to that of the ovaria and uteri. The gland itself is composed of from 150 to 200 elongated subcylindrical lobes, disposed in an oblong flattened mass, converging to a small oval areola in the abdominal integument, situated between three and four inches from the cloaca, and about one inch from the mesial line. It is situated on the interior of the panniculus carnosus, the fibres of which separate for the passage of the ducts to the areola; the orifices of these ducts are all of equal size, and occupy an oval space five lines in length by three in breadth; not elevated however in the slightest degree above the surrounding integument. An oily fluid may be expressed from the ducts by squeezing the gland.

A minute description is then given of the anatomical structure of the internal genito-urinary organs of the female *Ornithorhynchus*: from which it appears that if the animal be oviparous, its eggs must, from the narrow space through which they have to pass in order to get out of the pelvis, be smaller than those of a sparrow; and no provision appears to be made for the addition of albumen or of shell in the structure of that part of the canal through which they afterwards descend previous to their expulsion from the body. The ova are enveloped in a tough fibrous membrane in which the traces of vascularity, at least after being preserved in spirits, are not perceptible; whilst in birds the ova are attached by narrow pedicles, and are covered by a thin and highly vascular membrane.

From the whole of this inquiry, the author concludes that these glands are not adapted to the performance of any constant office in the economy of the individual, but relate to a temporary function. Their total absence, or at least their rudimentary condition, in the male, of which the author could perceive some traces in one specimen which he examined, and the greater analogy of their structure to a lacteal apparatus than to that of ordinary odoriferous glands, when taken in conjunction with the correspondence of their development to that of the uterine system, induce him to believe that they are to be regarded as real mammæ. This view is confirmed by the fact, noticed by Mr. Allan Cunningham, that the young of this animal readily takes cow's milk, and may be kept alive by this kind of sustenance.

7. "A Physiological Inquiry into the Uses of the Thymus Gland," by John Tuson, Esq. Communicated by J. C. Carpue, Esq. F.R.S.

The author is of opinion that the thymus gland is intended for two purposes: the one to serve as a receptacle of blood for supplying the chasm in the circulation occasioned by the great quantity sent to the lungs as soon as the function of respiration commences: the other to serve as a receptacle of osseous matter preparatory to the extensive ossification which is carried on in the early periods of growth.

8. "An Investigation of the Powers of the simple Supporters of Combustion to destroy the virulence of Morbid Poisons, and of the poisonous Gases, with a view to ascertain the possibility of controuling the extension of contagious or epidemic Diseases," by Edward Browne, Esq. F.L.S. Communicated by J. H. Green, Esq. F.R.S.

The author, after giving an account of the diversity of opinions entertained with regard to the power of chlorine gas to destroy contagion, states that this gas exerts a similar disinfecting power on the virus of small pox, and mentions the result of some experiments he tried on gonorrheal matter, on which it appeared to effect a similar change. Various experiments are stated to have been made with iodine and with oxygen, indicating the same disinfecting agency in these substances. The author conceives that these effects are promoted by the heat communicated to the respired air in the lungs. He conceives that sea air possesses a disinfecting power, which he explains by supposing that it contains a portion of iodine. He conjectures, from analogy, that fluorine and bromine may have the same property.

9. "Considerations on the Laws of Life, in reference to the Origin of Disease," by Adair Crawford, M.D. Communicated by T. J. Pettigrew, Esq. F.R.S.

The scope of this paper is to show the insufficiency of all theories which attempt to account for the phenomena of the living body, either in health or disease, by an exclusive reference either to the solids or to the fluids which enter into its composition ; or to the influence of an abstract and unknown principle of life ; or to that of physical or chemical agents ; or to the functions of the nervous, or of the vascular systems. For the establishment of the sciences of physiology and pathology upon the most solid foundations, the author is of opinion that all the circumstances above mentioned should be duly taken into account, and allowed their respective and proportionate degree of influence.

10. "On the Water Barometer erected in the Hall of the Royal Society," by J. F. Daniell, Esq. F.R.S. Professor of Chemistry in King's College, London.

The author having long considered that a good series of observations with a water barometer would be of great value as throwing light upon the theory of atmospheric tides, of the horary and other periodic oscillations of the barometer, and of the tension of vapour at different temperatures, was desirous of learning whether any such series of observations had ever been made. But he could meet with none having any pretensions to accuracy ; for neither those of Otto Guericke, in whose hands the water barometer was merely a philosophical toy, nor the cursory notices of the experiments of Mariotte upon this subject contained in the History of the French Academy of Sciences, can be considered as having any such claim. The difficulties which opposed the construction of a perfect instrument of this kind long appeared to be insurmountable ; but the author at length proposed a plan for this purpose, which, having been approved of by the late Meteorological Committee of the Royal Society, was ordered by the President and Council to be carried into execution.

The author then enters fully into the details of the methods he employed for constructing the whole of the apparatus, and for placing it in its present situation in the centre of the winding staircase conducting to the apartments of the Royal Society. The tube was very skilfully made by Messrs Pellatt and Co. at the Falcon Glass-house. It was 40 feet long, and one inch in diameter at its lower end; and so nearly cylindrical, throughout its whole extent, as to diminish only by two tenths of an inch at its upper end. A second tube of the same dimensions was also made as a provision in reserve against any accident happening to the first. These tubes were both securely lodged in a square case by means of proper supports. A small thermometer with a platina scale, was introduced into the upper end of the tube. An external collar of glass was united to that end by heating it. This was done with a view of giving it additional support, and of preventing it from slipping. This end of the tube was then drawn out into a fine tube ready for sealing with the blowpipe; and a small stopcock was fitted on to it. The cistern of the barometer was formed by a small copper steam boiler, 18 inches long, 11 wide, and 10 deep, capable of being closed by a cock, and having at the bottom a small receptacle for holding the lower end of the tube, so as to allow of the water in the cistern being withdrawn, without disturbing that contained in the tube.

The boiler was set with brickwork, in a proper position, over a small fire-place. It was nearly filled with distilled water, which was made to boil thoroughly so as to free it from air; and the cock being then closed, the water was raised in the tube by the pressure of the steam collected in the upper part of the cistern. The tube, when filled, was hermetically closed at the top: a proper scale, constructed by Newman, was applied to it, great care being taken to determine its height and to ensure the accuracy of its adjustments, and the precision of its measurements, by an exact mode of reading; and also to provide proper corrections for temperature. The water in the cistern was protected from contact with the air by being covered with pure castor oil to the depth of half an inch. The mercurial barometer employed as a standard of comparison, was of a portable construction, and was provided with a platina guard.

An account is then given of some of the results of the observations made with this water barometer, arranged in several sets of tables. The great object was to obtain good and uninterrupted series of observations, taken, at least once a day, at a fixed hour. The registers given by the author, contain such observations, continued for nearly a year and a half, namely, from October 1830 to March 1832. Some curious results are afforded by these observations. In windy weather the column of water is found to be in perpetual motion, not unlike that from the breathing of an animal. Many considerable fluctuations in the pressure of the atmosphere are rendered sensible by the motions of an aqueous column, which would totally escape detection by the ordinary mercurial barometer. Mr. Hudson remarked in the course of his observations, that the rise and fall of the water-barometer precedes by one hour the similar motions of the

mercurial one. The most striking result of the comparison between the two, is the very near coincidence of the elasticity of the aqueous vapour, as deduced from the experiments, with its amount, as determined from calculation, in a range of temperature from 58° to 74° . But a gradually increasing difference was at length perceptible, showing that gaseous matter had by some means insinuated itself into the tube. When this became no longer doubtful, the boiler was opened, and it was found that a portion of the liquid oil had escaped; and that the remainder had become covered with large flakes of a mucilaginous substance, by means of which it is probable that a communication had been established between the air and the water. The water had, however, retained its purity, and no indication was afforded of the metal having been anywhere acted upon. The author recommends that if these researches are prosecuted, the water should be covered with a stratum of oil of four or five inches in depth, which he has reason to think will form an effectual barrier to all atmospheric influence.

11. "Hourly Observations on the Barometer, with experimental investigations into the phenomena of its periodical oscillation," by James Hudson, Assistant Secretary and Librarian to the Royal Society. Communicated by J. W. Lubbock, Esq. M.A. V.P. and Treas. R.S.

Mr. Lubbock having found, from his examination of the meteorological observations made daily at the Royal Society, that they afforded no satisfactory result as to the daily variation of the barometer in consequence of the too great length of the intervals between the times of observation, the author undertook the task of making a series of hourly observations for a period sufficiently extensive to furnish preliminary data for explaining the anomalies of the barometrical oscillations. The present paper contains these hourly observations, amounting to about 3000 in number, and made in the months of April, May, June, and July, 1831, and in those of January and February of 1832. The standard barometer of the Society has been observed for about 16 or 18 hours during the day, through a period of 75 days; and also at every hour, through the whole twenty-four hours, for 30 days: the water barometer every hour, day and night, for 15 days; and the mountain barometer also every hour, day and night, for the same period. The relative levels of the surfaces of the fluids in the cisterns of each of these barometers, were accurately determined by Mr. Bevan. The most striking results afforded by these observations are exhibited by means of linear representations in four drawings which accompany the paper. The respective variations from each general mean, being referred, according to a given scale, to the mean line, and their points of distance from it, at each successive hour, being connected together by straight lines, the barometrical and thermometrical changes being each referred to the same scale, exhibits the striking connexion that exists between them. The comparison of the simultaneous movements of the three barometers shows the general accordance of their mean variations; and the precession in time, by about an hour, of the mean motions of the water barometer over those of the stand-

ard barometer ; and also the precession, by the same interval, of the mean changes of this latter instrument over those of the mountain barometer. The author concludes by announcing many objects he has in view in the investigations in which he is at present engaged.

12. "Note on the Tides in the Port of London," by J. W. Lubbock, Esq. V.P. and Treas. R.S.

The author gives a comparative view of the predicted times of high water deduced from Mr. Bulpit's tables, White's Ephemeris, and the British Almanac, with the observations at the London Docks, from data furnished to him by Mr. Stratford ; and also a comparison, by Mr. Deacon, at the London and St. Katherine's Docks.

13. "Researches in Physical Astronomy," by the same.

In this Paper a method is given of developing the disturbing function, in which the coefficients of the inequalities corresponding to any given order, are expressed in terms of the coefficients of the inferior orders ; so that, for example, the coefficients of the terms in the disturbing function, multiplied by the squares of the eccentricities, are given analytically by means of the coefficients of those independent of the eccentricities, and of those multiplied by their first powers. As the theorems, to which this method gives rise, are of great simplicity, the author considers them as deserving attention.

The Society then adjourned over the Long Vacation, to the 15th of November.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1832-1833.

No. 11.

November 15, 1832.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer,
in the Chair.

A paper was read, entitled "On some Properties of Numbers in Geometrical Progression." By Charles Blacklewar, Esq. B.A. Communicated by J. G. Children, Esq. Sec. R.S.

This paper contains the demonstrations of the three following theorems; namely,

1°. If the terms of a geometrical series be raised to 2^n , then any odd number of them is divisible by the corresponding terms of the original series.

2°. If each term of a geometrical series be raised to any odd power, the sum of the terms so raised is divisible by the original series, if the number of terms taken be any power of 2.

3°. If the number of terms of a geometrical series be any power of 2, the sum of the terms raised to the power m is divisible by the sum of the same terms raised to the power n , provided m divided by n be a whole number.

November 22, 1832.

JOHN BOSTOCK, M.D. Vice-President, in the Chair.

A paper was read, entitled "Account of an Improvement in the Machine for producing Engravings of Medals, Busts, &c. directly from the Objects themselves, in which the Distortions hitherto attending such Representations are entirely obviated." By Mr. Bate. Communicated by J. G. Children, Esq. Sec. R.S.

Some printed representations of medals having been received from America, about fifteen months ago, evidently effected by some process of ruling, Mr. Bate, jun. constructed an instrument for accomplishing the same object; but the results, both of the American method and of the one invented by Mr. Bate, were attended with a degree of distortion. This the author has ingeniously obviated, by giving an inclination of 45 degrees to the plane in which the tracing-line is moved over the surface of the object of which a representation is to be given.

A paper was also read, entitled "An Account of the Construction of a fluid refracting Telescope of eight inches aperture and eight feet nine inches in length, made for the Royal Society by George Dollond, Esq. F.R.S." By Peter Barlow, Esq. F.R.S.

The author has, in former papers read to this Society, pointed out the great variety of cases included under the general formulæ relating to the operation of fluid refracting telescopes, and stated the difficulty of selecting, independently of experiment, the particular case which was likely to produce the best result. This subject is pursued in the present paper; and the principles and calculations stated at length which the author has applied in the construction of the telescope which the Council of the Royal Society directed should be made by Mr. Dollond, under the superintendence of the author, in order to put these principles to the test of experiment, and to decide the question of the expediency of proceeding in the construction of a similar telescope of much larger dimensions. When the experimental telescope was completed, it was found that its performance agreed in every respect with the computed results, as well in focal distance as in chromatic and spherical aberration. The arrangement of the lenses was such, that the corrections are all of them made in the transmission of the light through the fluid, and by the fluid only. The author abstains from offering any remarks on the performance of this telescope, leaving it to those whom the Council of the Royal Society may appoint, to decide upon its merits. He concludes by expressing his obligations to Mr. Dollond, for the readiness with which he complied with all the suggestions of the author, and for the accuracy with which he has executed every part of the instrument.

Anniversary Meeting, Nov. 30th.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The President delivered the following Address :

GENTLEMEN,

THIS is the Second Anniversary of my election to the Chair of the Royal Society, and I gladly avail myself of the opportunity which it affords me of renewing the expression of my gratitude to you for the distinguished honour conferred upon me in electing me to it, and still more for the continued kindness and support which I have received from you in the execution of the duties of my office. I can only assure you, Gentlemen, that if it be your pleasure that I should continue to fill this Chair, I shall feel an additional motive to induce me to devote my most earnest attention to the promotion of the interests of the Society, in the perfect reliance which I place upon your cooperation and assistance, and in the confident expectation which I entertain, that in case I should fail in the due and efficient discharge of any of my duties, I shall experience from you the most kind and liberal interpretation of my motives and conduct.

In making my acknowledgments to the Fellows of the Society at

large for their uniform kindness and support, it would be injustice and ingratitude on my part were I not to return my public and especial thanks to the Vice Presidents, Treasurer, Secretaries, and the other Members of the Council—

To the Vice Presidents, as well for their general services as also for their kindness in supplying my place in this Chair, when I have unfortunately been compelled to be absent from the state of my health, or from the immediate necessity of discharging other most pressing public duties.

To the Treasurer, for his vigilant attention to the finances of the Society, and to every arrangement which may in any manner tend to promote the usefulness of the Institution, and increase the accommodation of its Members.

To the Secretaries, for their courteous discharge of their various and very laborious duties: and to the Members of the Council collectively, for their regular and punctual attendance at all the meetings to which they have been summoned, and for the zeal and readiness with which they have undertaken any labour, however considerable, which the interests of the Society might require them to perform.

The Report of the Council which will be read to you by one of your Secretaries, Dr. Roget, will make known to you various matters connected with the administration of the Society, and also the arrangements adopted for supplying the deficiencies of the Library in different departments of science, and for rendering it more generally accessible, and therefore more useful, by means of complete and well classed catalogues. I must refer you likewise to the same Report for a statement of the grounds upon which two Copley Medals have this year been adjudged, one to Mr. Faraday, and the other to Mons. Poisson. There is, however, one arrangement, admirably calculated, in my opinion, to increase the usefulness and to uphold the credit of the Royal Society, which that Report does not notice; I mean the Resolution adopted by the Council to allow no Paper to be printed in the Transactions of the Royal Society, unless a written Report of its fitness shall have been previously made by one or more Members of the Council, to whom it shall have been especially referred for examination. This Resolution has been acted upon for the greatest part of the last year, and some of those Reports of a favourable nature have been read before the Society, and printed in the Abstracts of our Proceedings. When the number of papers which come before the Society in the course of a year is considered, as well as the great diversity and occasional difficulty of the subjects which they embrace, it will be at once seen how greatly the labours and responsibility of the Members of the Council must necessarily be increased by the rigorous adoption of such a system. It is in consequence of the important influence which this plan is likely to have upon the well-being of the Society, that I am induced to enter somewhat in detail into the reasons which have led to its adoption.

It has long been the custom of many Foreign Societies, and particularly of the Academies of Science and of Medicine at Paris, to require written Reports upon every paper submitted to them,

from a Committee of their Members: as the persons who are selected for this duty are frequently veterans in their respective sciences, who have earned by their labours an European reputation, the Reports which are thus produced prove often more valuable than the original communications upon which they are founded, and the collections of them, as is well known, form a most important part of the stock of modern science. Many other advantages also have been found to result from the adoption of this practice. The decisions of men who are elevated by their character and reputation above the influence of personal feelings of rivalry or petty jealousy, possess an authority sufficient to establish at once the full importance of a discovery, to fix its relations to the existing mass of knowledge, and to define its probable effect upon the future progress of science. They thus operate as a powerful stimulus to the exertions of the genuine cultivators and lovers of science, who feel assured that their labours will be properly examined and appreciated by those who are most competent to judge of their value; whilst, at the same time, they tend to keep under the obtrusive and turbulent pretensions of those who presume to claim a rank as men of science, for which they possess no just title or qualification.

It was from a conviction that many similar advantages would result from such a system of Reports in the Royal Society, that the Members of the Council were induced to agree to its adoption; and it is to be hoped that, when a longer experience has given to such a plan a more complete organization, and has shown the practical extent to which it can be conveniently carried, it will then become a permanent law of the Council.

In order, however, to secure its full advantages, it will be necessary that the Council should, in all cases, include men eminent for their proficiency in all those branches of science which usually come, or are likely to come, under the notice of the Society. That such men may be found, I feel satisfied, both from my past experience and from my knowledge of the many distinguished persons who adorn the lists of this Society; and that such men would generally be ready to undertake the performance of a duty, requiring the occasional sacrifice both of time and labour, I cannot venture to doubt, without imputing to them a charge of indifference to the interests and the usefulness of the Royal Society, and even a want of proper sympathy with the scientific honour of their country.

I think myself justified in using such strong language, Gentlemen, because I believe the scientific character of this country to be most intimately associated with the scientific character and estimation of the Royal Society. One of the most illustrious of modern mathematicians and philosophers, himself a foreigner, has said that the Royal Society has contributed more to the progress of science than the combined labours of all other similar institutions; and though it would be unfair to interpret too literally the language of a compliment, yet it would not be very difficult to vindicate its general truth and justice.

It was this Society which fostered and encouraged the early labours

of Newton, and under its auspices was published the work which constitutes, and probably ever will constitute, the proudest monument of the genius of man: and from the period which immediately followed its foundation, the age of Wallis, and Newton, and Wren, and Hook, and Halley, and Taylor, to that of Herschel and Cavendish, and Wollaston, and Young, and Davy, its Transactions contain records of almost every important discovery in natural philosophy; of almost every experimental inquiry which has been most remarkable for its difficulty, delicacy, or importance; and of almost every original speculation which has most contributed to the advancement of science.

It becomes us therefore to guard these national archives of the progress of knowledge, with the reverence which is due to them as monuments inseparably connected with our own national honour; and to watch with our utmost care, lest any addition should be made to them, which can be considered as unworthy of the character of the stock upon which it thus becomes engrafted; and it therefore is the bounden duty of every Fellow of this Society, whether it be considered as imposed on him by the terms of the Obligation which he signed at the period of his admission as a Member, or as derived from the still higher and more comprehensive ties which bind every friend of the great institutions of his country, to maintain their efficiency and credit, and to allow no private or personal cause of jealousy or discontent, no trivial or unfounded plea of want of leisure from business, or occupations, to interfere with the devotion of his best exertions to uphold the character and promote the interests of the Royal Society.

There are some reasons which I know may, and very probably will be urged against the reasonableness of expecting that any considerable number of men of science, should be able, however willing they might otherwise be, to devote any large portion of time or labour to the service of any Society, let its claims upon them be ever so strong.

In this country, where wealth is the general measure of the social rank of families at least, if not of individuals, men of science must either possess an independent fortune, or they must pursue it, as is most generally the case, in connexion with a laborious profession; for we have few establishments which afford them support, independently of other employments; and even in those very rare cases, the provision which is made is so small, that no man of superior education can look forward to the attainment of the advantages which science and learning offer, in forming his scheme of life, unless he be prepared to make the most serious sacrifices. It is for this reason, that the learned professions, presenting as they do the most brilliant prospects of rank and wealth, generally absorb, in the progress of life, the studies and exertions of young men of the highest scientific education and promise; for, however strong may have been their attachment to the studies of their youth, and however ardent their ambition to obtain the honours of science, they soon find that such pursuits retard their professional advancement.

In other countries, however, where the learned professions are neither richly paid nor highly honoured, and where the exclusive cultivation of particular branches of literature and science presents the readiest access to the possession of competence and social rank, we find large bodies of men who have no professional engagements whatever to divert them from their literary and scientific labours, which are thus made to constitute the business of their lives. I am fully sensible of the great advantages which other countries possess in these respects above our own, and that it is quite impossible for us to command an equal concentration of attention to the advancement of particular branches of science, or to the concerns of a particular Society; still less so when it is considered, that those services must with us be afforded gratuitously, which in other countries are remunerated by the State, or are required as part of the duty of a salaried office:—we are not less called upon, however, on this account, to make the best and most efficient use of the means in our power, and the assistance which we cannot command as due from a sense of official or professional obligation, we may receive as rendered from a higher feeling of devotion to the promotion of the general interests of science, and with it of our national fame.

However much I may lament the want of establishments, in this country, for the exclusive and liberal support of men of learning and of science, and however anxiously I may look forward to the time when our Government and Legislature may take this subject into their most serious consideration, with a view to the remedy of so great an evil, yet I rejoice to observe amongst all ranks of society so zealous and so ardent a feeling in favour of the cultivation of every branch of science, of art, and of literature; so general and so deep an anxiety, in fact, that our country should advance in the front rank in the rapid march which European nations are making in knowledge and improvement.

It would be very easy for me to produce evidence of the existence of this spirit in the foundation of literary and other Societies in so many of our provincial towns, and in the active and general support which they receive; but it is sufficient for my purpose to appeal, for the complete confirmation of the truth of the opinion which I have expressed, to the noble manner in which the British Association has been supported, by the eager concurrence of the friends of science from all quarters of the kingdom: and the splendid reception which has been recently given to this Association by the University of Oxford; the judicious and well merited honours conferred upon four of its most illustrious Members*; the eager attention which was given to its proceedings by crowds of intelligent and admiring auditors, the great variety and excellence of the Reports which were there produced upon the present state and recent history of various branches of philosophy, will constitute a proud epoch in the scientific history of this country, and one which is full

* Brewster, Brown, Dalton and Faraday, on whom the degree of LL.D. was severally conferred.

of promise with respect to the future state and fortunes both of science and its cultivators.

It becomes my duty now to advert to the heavy and severe losses which the Society has sustained during the last year, including, I regret to say, many celebrated names, more particularly in our foreign list. I shall begin, however, with the mention of those names upon our home list, whose labours in the cause of literature or of science, appear to entitle them to particular notice.

Sir Everard Home, Bart., was born at Hull on the 6th of May 1756. He was the youngest son of Robert Home, a surgeon in the army, and descended from the Barons of Polwarth, the ancestors of the Earls of Marchmont in Scotland: he was educated at Westminster School, and though elected off as a scholar to Trinity College, Cambridge, in 1773, he never went there, having abandoned his prospects in college upon the invitation of the celebrated John Hunter, who had recently married his eldest sister, and who offered to superintend his education in surgery and human and comparative anatomy, and gave him the free use of his unrivalled collections. Under his auspices he continued to study for several years, availing himself at the same time of the lectures and instructions of the most eminent anatomical and medical teachers of his day. He went to the West Indies upon the medical staff in 1780, where he remained for four years; upon his return to England in 1784, he continued to assist Mr. Hunter in the arrangement and completion of his museum, and also in his various official duties until his death, which took place in 1793. Mr. Home was elected a Fellow of this Society in 1785; in 1808 he was made serjeant-surgeon to the King, and in the same year he received the Copley Medal for his various papers on Anatomy and Physiology, printed in the Philosophical Transactions. In 1812 he was created a baronet, being the first surgeon in actual practice upon whom that honour had been conferred.

In 1821 he was appointed surgeon to Chelsea Hospital, and in the following year he was elected President of the College of Surgeons. In the year 1827 he began to retire from the practice of his profession, and from most of his official employments; and he died at his residence in Chelsea College in August last, in the 77th year of his age.

Sir Everard Home was the author of 107 papers in the Transactions of this Society, a number exceeding that of any other contributor. He published Lectures upon Comparative Anatomy, in six volumes quarto; the two first in 1814, the third and fourth in 1823, and the two last in 1828. They consist chiefly of the results of his papers in the Transactions of this Society, with a republication of the splendid plates, by the permission of the Society, by which many of them were illustrated. He was also the author of several other works upon different subjects of anatomy and surgery; and he published in 1797, *Memoirs of John Hunter*, who had bequeathed to him all his papers.

Sir Everard Home must be considered as the successor of John Hunter, and in every way most closely connected with him. He

aided greatly in the formation of his noble collection ; he was a witness of, and a sharer in, his most important investigations ; he was also the depository of his literary treasures ; and if we regard either the number or the nature of his anatomical or physiological researches, and the importance of his discoveries, we must be compelled to declare that he followed closely and worthily in the footsteps of his illustrious predecessor : but though he was a most diligent observer and collector of facts, and fully qualified, by his extensive knowledge of anatomy and physiology, to collate them with existing materials of those sciences, and to reduce them, as he has done in his lectures, to a regular and well-connected system, yet we should be unjust to the memory of that great man who was his instructor and patron, if we ventured to place him in the same rank with him. But what name in modern times, if that of Cuvier be excepted, can be put in competition with that of John Hunter, for careful and philosophical induction, and for the power of concentrating facts derived from most extensive observations upon every part of the animal kingdom, in illustration and confirmation of his physiological theories ? It would be unfair to the memory of Sir Everard Home to subject his merits and his fame to be tried by so severe a test ; rather let us ask, when the vast range of his knowledge and investigations is considered, who were his rivals or his superiors among his contemporaries, or amongst his survivors ?

Sir James Hall, Bart., the author of several important papers in the *Edinburgh Transactions*, in illustration and in defence of the Huttonian Theory, and of a very ingenious and speculative book on the *Origin of Gothic Architecture*, is another considerable name, whose loss we have to deplore.

In considering the present state of geological science, we are too apt to forget the fluctuations of opinions and of theories through which we have passed in order to arrive at our present state of comparative repose. It is little more than twenty years since the partisans of Hutton and of Werner divided between them the geological world, and we rarely hear their names now pronounced ; not that their names have passed into oblivion, but that their theories and their speculations have become a portion of the history of the science, and no longer form a part of the debateable materials of which it was, or was not, to be constructed. Sir James Hall, in conjunction with his friend Professor Playfair, was, in the early part of the present century, an ardent vindicator of the opinions of Dr. Hutton ; and it was with a view to the removal of some of the more popular and startling objections to his theory, that he undertook, and continued during several years, those memorable experiments upon the effects of compression in modifying the action of heat, which have contributed so greatly to the termination of the controversies which were then agitated with so much warmth and severity. These experiments, most happily conceived, and executed with singular boldness and perseverance, completely proved that the most refractory substances may be made fusible by confining the elasticity of the gaseous parts contained in them. Thus, pounded carbonate of

lime or chalk could be rendered fusible, without calcination, and became, upon cooling, a compact stony mass, and even crystalline, like marble: it thus appeared that the effect of heat, acting under enormous pressures, would not necessarily dissipate the gaseous and evaporable parts of the strata of the earth, but would leave them to form such new combinations or modifications of existence as might be determined by the laws of crystallization or of chemical affinities;—a most important fact, and one apparently so difficult to establish in a form which might bring into action those gigantic forces which present themselves in the great operations of nature, as would have checked the attempts of any man who was not urged onward by the most determined enthusiasm in the defence of a favourite theory.

Sir James Hall's work on the Origin of Gothic Architecture cannot be considered as a serious archæological inquiry, but rather as an agreeable exercise of his fancy. The development however of his theory is singularly ingenious and elegant; it proves him to have possessed no mean talents as an artist, and shows a mind alive to all those beautiful combinations of nature which seem to be rendered fixed and permanent in the naves of our Gothic cathedrals, and in the tracery of our decorated windows.

Sir James Mackintosh was born in Morayshire in Scotland, in 1765; he was the son of an officer, of good family, but of very limited fortune; his first destination was for the profession of medicine, and with this view he took the degree of M.D. at Edinburgh, in 1787. Upon his removal, however, to London, shortly afterwards, he abandoned his medical prospects, and gave himself up entirely to the study of the law, and of moral and political philosophy. In 1789 he went to Leyden, where he studied for some time, and afterwards to Liege, where he was a witness of the memorable struggle between the Prince Bishop and his subjects, as well as of many other ebullitions of popular feelings which preceded and foreboded the French Revolution. It was, probably, the contemplation of scenes like these, as well as the observation of the corruptions and abuses of many of the continental governments of Europe, which made him, like many other ardent young men of that period, an admirer of the principles of that great national movement; and the *Vindiciæ Gallicæ*, a work of great force and eloquence, was the most powerful answer which appeared in that age to Mr. Burke's celebrated Reflections, and gained for him, at once, both at home and abroad, a distinguished reputation. The atrocities, however, which marked the more advanced stages of the French Revolution, his own increasing experience and knowledge of mankind, and still more his frequent intercourse with his illustrious adversary, for whose genius he had always professed a chivalrous admiration, however much he had opposed his views and his reasonings, combined to sober down the fervent enthusiasm of his own youthful speculations and hopes; and the principles which he avowed and vindicated in his celebrated defence of Peltier in 1802, must be considered as those which he adopted as the result of the convictions of his maturer age, and

which he continued to maintain through life. In 1803 he was appointed Recorder of Bombay, where he resided for seven years, and where he secured the affection and admiration both of natives and of foreigners, by the able, impartial, and considerate discharge of his judicial functions. Upon his return from India in 1811, he was elected Member of Parliament for Knaresborough, a place which he continued to represent for the remainder of his life.

Few persons of his own age had read so much as Sir James Mackintosh, or remembered what they had read so well. His conversation was singularly instructive and brilliant, without being overbearing; his manners were conciliating, his temper excellent, and he was entirely tolerant of opinions which were different from his own. He was one of the most distinguished Members of the House of Commons; and his speeches upon all the great questions which were agitated in his time were remarkable, not merely for their eloquence, but the large and comprehensive views of national policy, which were supplied by his almost unrivalled knowledge of history and political philosophy.

Sir James Mackintosh, besides his *Vindiciæ Gallicæ*, was the author of Lectures upon the Laws of Nations; of A Sketch of the History of England; of an incomplete Essay on the Principles and the History of Moral Philosophy; and of many admirable Reviews. It is to be lamented that he should have dissipated his extraordinary powers upon occasional and desultory publications, instead of concentrating them upon some great work, which might have transmitted, undiminished, to posterity the reputation which he enjoyed among his friends and cotemporaries. There were, however, many circumstances which might sufficiently account for his failing to leave behind him a monument for future ages, which would have been worthy of his genius and his learning. He brought home with him from India a shattered constitution, which disqualified him for continued and laborious exertion; he had many Parliamentary as well as official duties to perform; and the pressure of his pecuniary necessities compelled him to seek, too frequently, for the immediate remuneration which was supplied by means of contributions to the perishable periodical literature of the day.

Colonel Mark Wilks went to Bengal in 1783, and served in different military and civil capacities in various parts of India. In the year 1804 he was appointed principal Resident at the Court of Mysore, and in the following year he published a very able Report upon the financial condition, resources, and many other subjects connected with the administration of the government of that country. He was the author of "Historical Sketches of the South of India, in an attempt to trace the History of Mysore to the Extinction of the Mohammedan Dynasty in 1799,"—a work of great learning and authority: he was afterwards appointed Governor of St. Helena, and he died in England in the course of the present year.

Colonel Wilks must be considered as one of those distinguished men who have been formed by the system of our Indian Empire. The possession of great commands, upon which the happiness and

misery of considerable nations are dependent, and the intense feeling of responsibility which is connected with the administration of trusts so important, is well calculated, under all circumstances, to call forth into action the highest powers of the human mind; and particularly so, when they have been previously exercised and fortified, as in our Indian service, by the severe study of Oriental languages, and by the successive occupation of different offices, with a great diversity of duties: it is to such causes that we are to attribute the frequent union which we observe in this service of the greatest civil and military talents with the most profound acquisitions in Oriental learning; it is to this system that we are indebted for the production of a Duncan and a Monro, an Elphinstone and a Raffles, a Colebrooke and a Malcolm, and a crowd of great men who have done so much honour to our Indian Government.

Alexander Barry, Professor of Chemistry to Guy's Hospital, and the author of a short paper in our Transactions for 1831, "On the Chemical Action of Atmospheric Electricity," fell a victim to the imprudent pursuit of his chemical inquiries. He was making experiments upon some gases in a highly condensed state, when an explosion took place, by the effects of which he was so much injured as to occasion his death shortly afterwards. He was elected a Fellow of this Society in the course of the last year.

John Shaw, Architect, is advantageously known to the public by several works in the Metropolis, particularly the great hall in Christ's Hospital, and the new church of St. Dunstan in Fleet Street: works which are extremely effective, and well adapted to their objects and positions.

Stephen Groombridge, Esq., was the author of two papers in our Transactions for 1810 and 1814, of considerable interest and value, upon the subject of astronomical refractions: his observations were made at his house at Blackheath, with a four-feet transit circle, which has acquired no small degree of celebrity from its being the first instrument, after the Westbury Circle, to which Mr. Troughton applied his method of division, which he has described in our Transactions. Mr. Groombridge made many thousand observations, which have been reduced by order, and published at the expense of, Government,—a circumstance well deserving to be known by all astronomers, as he was an able and faithful observer, and possessed more advantages for making meridian observations than are commonly enjoyed without the walls of a regular observatory.

Sir Richard Hussey Bickerton was a very distinguished naval officer, who was employed in the service of his country for the greatest part of his life, and who was for some time second in command to Lord Nelson in the Mediterranean and elsewhere, and enjoyed his entire confidence and esteem. He was one of the Lords of the Admiralty from 1805 to 1812, a circumstance which brought him into frequent communication with the Royal Society, and led to his election as a Fellow in 1810.

In our list of Foreign Members, we have to record the deaths of Cuvier and of Chaptal in France, of the Baron de Zach in Germany,

and very lately likewise those of Oriani and of Scarpa in Italy; five celebrated names, which have long been intimately associated with the progress of science. The limits of this address must confine me to a very brief and imperfect notice of their merits and their labours.

The Baron Cuvier, the most illustrious naturalist of modern times, was born at Montbelliard in Alsace, in 1769, and died on the 13th of May last, in the 63rd year of his age: it is not necessary for me to detail any of the circumstances of the life of one whose name has been long known and revered in every region of the globe which has enjoyed the blessings of European civilization; suffice it to say, that he was honoured and even courted by every Government in France from the period of the Convention to the present day; that he held the most lucrative and distinguished appointments which the wise policy of that great nation has provided for the honourable support of its men of science and literature; that after the death of Laplace he was universally regarded by his countrymen as the most illustrious of their men of science, and as one of the most distinguished of their men of literature; that funeral orations were pronounced over his grave by men of all political parties, however much opposed to him during his life; and mathematicians and naturalists, geologists, historians and poets, all felt themselves impelled to pay this last tribute of homage to the genius of one, who in so many capacities had done so much honour to his country.

M. Cuvier was in every respect a most extraordinary man: his very presence was calculated to command respect, his countenance bearing that impress of a powerful intellect, which all men recognise when seen, however difficult it may be to define its character: his manners were dignified and polished, and his conversation possessed that happy ease and subdued gaiety which characterized the best age of French society. He was well acquainted with ancient literature, and familiar with the principal languages of modern Europe. His memory was singularly accurate and retentive; and his knowledge of facts, not merely in those sciences which he especially cultivated, but likewise in all other departments of knowledge, and particularly history, was a subject of surprise and admiration to all who knew him. He was also eminently distinguished as a writer of his own language, and his numerous *éloges* delivered in his capacity of *secrétaire perpétuel* to the Institut, of which three volumes have been published, if considered as specimens of composition merely, have equalled, if not surpassed, the best examples of a species of eloquence of which the French nation has just reason to be proud; but if they be considered as specimens of correct and precise discrimination of the merits of the persons commemorated, as determined by their writings and discoveries, and by the influence which they have exercised upon the progress of knowledge, they may justly be pronounced to be unrivalled. It was to this publication that he was indebted for his place amongst the *forty* of the *Académie Française*, an honour which he alone, in his own age, enjoyed in conjunction with his place in the *Académie des Sciences*.

It is, however, chiefly as a naturalist that Cuvier must be viewed, when we seek to determine his permanent rank amongst the few great men who have effected great revolutions in the sciences which they have cultivated, or have left ineffaceable traces of the influence of their discoveries behind them. The whole animal kingdom, from the most obscure indications of the separation between inanimate and animate existence to the mighty monsters of a former world, has assumed under his hands a systematic arrangement, not founded upon superficial and unimportant external characters merely, but upon a most careful and laborious observation of the analogies of internal structure. By tracing every organ successively through the whole series of animals; by carefully determining the functions of such organs and their relations to each other; and by considering them in every animal in the first place as an individual, and in the second place with reference to others, he has been enabled to distribute them into species and genera, and families and classes, where every successive step in their arrangement is the result of a legitimate and inductive generalization. It is by such means that he has been enabled to convert the science of natural history, at least in the animal kingdom, from being little more than a systematic classification, formed for the purpose of identifying genera and species and with no higher view, into a science of strict and severe induction, founded upon a careful observation and comparison of every fact which anatomical and physiological science can detect, and thus to confer upon it a dignity which is only inferior to that of the physical sciences.

It has resulted also, from his researches, that every animal considered as one of the same genus or species, is not only an individual considered as a whole, but also when considered in all its parts; in other words, that every bone, every muscle, every organ, and every part of its structure is *essentially* distinguished from the corresponding parts of an individual of any other genus or species. To a perfect naturalist, therefore, the inspection of a bone, or any other part of an animal, would bring to his mind the entire animal itself, and would identify it as perfectly as if it was exhibited entire to his eye: this would be a triumph of science to which our limited knowledge and faculties can never completely attain; but it was to this point that Cuvier approximated, when he reconstructed as it were the fossil animals of an antediluvian world from the imperfect fragments which remained of them; when he showed in what such animals must have differed, and in what they must have agreed, whether in magnitude or in kind, from the animals which exist at present; when he ventured in fact to define their habits, and to write as it were the natural history of a former world, by throwing upon its obscure and half-obliterated records the powerful light of science and philosophy. The *Histoire des Ossements fossiles* must ever remain a classical work to geologists; and the discoveries which it contains, and those to which it has led in the hands of others, are some of the most interesting and extraordinary with respect to the past ages of the world, which ob-

servations upon the surface of the globe have ever enabled us to ascertain.

The last great work upon which he was engaged was the *Histoire Naturelle des Poissons*, a prodigious undertaking, of which eight volumes have been published, and which he expected to extend to twenty-five: it was undertaken in conjunction with Messrs. Valenciennes and Laurillard, to whom also he has bequeathed the task of completing it. It will contain the description of 6000 species of fish, 4000 of which had not been noticed in any other work.

Jean Antoine Chaptal, Comte de Chanteloup, was born in 1756, and died in April last in the 76th year of his age. He was Professor of Chemistry at Montpellier before the Revolution, and was one of the most active cultivators of chemical science before that event, in conjunction with Monge, Fourcroy, Berthollet, Guyton de Morveau, and the illustrious Lavoisier. In the year 1793, upon the threatened invasion of France by the Allies, when saltpetre was not to be procured in sufficient quantities for the manufacture of the powder wanted by the French armies, he was invited by the Committee of Public Safety to superintend the establishments for that purpose; and his chemical knowledge so greatly improved the method followed in its manufacture, as in a very short time to make the produce greatly exceed the demand. He was made *Ministre de l'Intérieur* by Napoleon, and continued under the Empire to fill many important situations. He was the author of considerable works on chemistry, on the application of chemistry to the arts, on the application of chemistry to agriculture, on the art of making wines, and on the art of dyeing cotton and wool, which are written in a very perspicuous and elegant style, and which have enjoyed a very considerable popularity in France. The labours of his whole life, in fact, were devoted to the improvement of those manufactures whose perfection depended more or less upon the most correct and economical application of chemical principles; and, after his distinguished countryman Berthollet, he must be placed in the first rank of those who have benefited the arts through the medium of chemical science.

François Xavier Baron de Zach was born at Pesth, in Hungary, in 1754. His taste for astronomy was decided at the early age of fifteen, by the interest which he took in the observation of the comet of 1769, and by the transit of Venus over the disc of the sun in the same year, a memorable event which served to make more than one important convert to the science of astronomy. After travelling with scientific views through different countries of Europe, and residing for several years in England, where he acquired for our manners and institutions an attachment which continued throughout his life, he settled at Gotha, in 1786, in the family of the Duke of Saxe Gotha, who charged him with the construction of the Observatory at Seeberg, over which he continued to preside for a considerable period. He published at Gotha, in 1792, *Tables of the Sun*, with a *Catalogue of 381 Stars*, and he subsequently published many other

important astronomical Tables, particularly those on Aberration and Nutation. He became in 1800 the editor of the "*Monatliche Correspondenz*," a German periodical work on astronomy and geography, which was subsequently published in French under the title of "*Correspondance Astronomique &c.*," upon his removal to the South of France in 1813, and subsequently to Genoa in company with the Duchesse de Saxe Gotha. This was a most valuable Journal, containing records of the progress of astronomy in every country in Europe, and contributing more than any other publication to the great impulse which has been given for many years to the cultivation of astronomical science in Germany. In 1814 he published his very interesting work on the "*Attraction of Mountains*." For many of the later years of his life he suffered severely from the stone, and he had established himself at Paris for the purpose of being constantly under the care of Dr. Civiale and experiencing relief by the operation of lithotritry, where he died from a sudden attack of cholera in September last. The Baron de Zach was a most zealous friend to astronomy, and throughout his long life contributed to its progress by his numerous publications, and by maintaining a most extensive and laborious correspondence with the principal astronomers in Europe. He was a man of warm and ardent affections, rapid and sometimes hasty in his conclusions, of the most lively and agreeable manners, and of the most indefatigable industry: and there are few persons of the present day whose loss will be more sensibly felt by the friends of astronomical science in every country in Europe.

Barnaba Oriani, Director of the Observatory of the Brera at Milan, where he has resided for fifty-five years as assistant and principal, was born at Garegnano near Milan, in 1753. He was the principal conductor of the measurement of an arc of the meridian in Italy, and of the great trigonometrical survey of Lombardy, which took place between the years 1786 and 1790; and throughout the course of a long life, he devoted himself to the cultivation of physical and practical astronomy. He was the first person who calculated the orbit of the planet Ceres after its discovery by Piazzi at Palermo. He published theories of the planets Uranus and Mercury, with Tables of their motions. He laboured with singular skill and perseverance in the improvement of the lunar Tables both by theory and observation. He was the author of an admirable treatise on spheroidal trigonometry: and the *Astronomical Ephemeris* of Milan was published for many years under his directions, by Carlini. Upon the whole, if the union of practical with theoretical science be considered, we shall be justified in pronouncing him to have been, after Bessel, the most accomplished astronomer of the present age.

Antonio Scarpa, one of the eight Foreign Members of the *Académie des Sciences* of Paris, and probably the most profound anatomist of the present age, was born in the year 1746, and died in October last in his eighty-seventh year. He was made Professor

of Anatomy at Pavia in the twenty-second year of his age, and for the last half-century he has been placed by the common consent of his countrymen at the head of their anatomists and surgeons. He was the author of magnificent and classical works on "The Organs of Hearing and Smell," "On the Nerves," "On the principal Diseases of the Eye," "On Aneurism," "On Hernia," with Memoirs on many other subjects of physiology and practical surgery. He had accumulated a handsome fortune by the practice of his profession, and had collected in his palace at Pavia a considerable number of works of art, where he lived for the latter years of his life, surrounded by his pupils, revered by his countrymen, and in the enjoyment and contemplation of that brilliant reputation, the full development of which a great man can rarely live to witness.

In thus directing your attention, Gentlemen, to those distinguished Members of the Royal Society, who, unhappily for the interests of science, have been taken from us during the last year, there is one name remaining which I cannot notice without feelings of the most painful embarrassment. To what class shall I, or can I refer it; to the living or to the dead? Though my fears tend too strongly to make me decide upon the choice of the latter, yet I would fain indulge in the hope which is still afforded by the uncertainty, mournful though it be, which hangs over the fate of the gallant and adventurous Captain Ross. The object of his voyage, as is well known to you, was the solution of a nautical problem of the greatest interest and difficulty,—the discovery of a north-west passage. It is a problem which more than any other excited and baffled the adventurous spirit of our most daring seamen of the age of Elizabeth; and when subsequently resumed, chiefly upon the authority of the ingenious speculations of Daines Barrington, a distinguished Member of this Society, and of others of later date, the first attempt of Captain Ross himself and the memorable voyage of Parry, as well as the journey of Franklin, have shown how visionary were all hopes of its successful solution for the purposes of commerce, however interesting it might be for those of science. It was the failure of the first voyage of Captain Ross, and the apparent censure which he conceived rested upon him, in consequence of the greater success of the attempt of his immediate successor in this enterprise, which oppressed his high and manly spirit, and made him seek, with the greatest possible earnestness, for an opportunity of vindicating his professional character. With the assistance of some of his friends he planned another voyage, and nearly three years ago he proceeded to put it into execution. It is to dispel the mystery attendant upon that voyage, of which no tidings have been yet received, and to relieve the misery under which the friends and relations of Captain Ross and his gallant crew are lingering, that a vessel is now preparing, under the command of an able and experienced officer, to pursue the track which he probably followed. I have consented, at the request of the Royal Geographical Society, to be placed at the head of the Committee which has been formed for the aid and

furtherance of this benevolent plan, and I confidently hope that the funds which are necessary to complete this undertaking will not be found wanting.

The name of nearly every distinguished foreigner who has been lost to science during the last year has appeared upon the Foreign List of the Royal Society, and I cannot help considering it as a circumstance which does honour to the Royal Society, that it should thus have associated with it whoever is most eminent in the great aristocracy of European science. It is my wish, Gentlemen, and I feel assured that it is yours also, that the Royal Society should embrace the name of every distinguished man of science in the British dominions. At the last Anniversary it was my pleasing duty to present the Copley Medal to Professor Airy,—a name which would do honour to any Society, but which does not yet appear in the list of our Members: and I lament that I am not allowed to commemorate the name of that very distinguished philosopher, Sir John Leslie, upon this occasion in the obituary of the Royal Society. I look forward with hope, Gentlemen, to the time when the Royal Society shall be so circumstanced as to be free from such a reproach, or rather from such a misfortune.

Report of the Council to the Anniversary Meeting on St. Andrew's Day, 1832.

THE Council of the Royal Society have, during the past year, used their most earnest endeavours to render the Library as effective for the purposes of science, as the means at their disposal would enable them. They have been desirous, in particular, to make it as complete as possible in all those departments of science, which it is more especially the object of the Royal Society to cultivate and to advance. They have accordingly purchased, with the advice of the Library Committee, such books as were more immediately required for these purposes, at an expense of about £1600. It was evident, however, that the mere possession of these books by the Society would be of little avail to those who wished to use them, until they were arranged and catalogued according to some uniform and well-digested method. A Committee was therefore appointed to consider of the best plan of effecting this desirable object; and to suggest measures for obtaining a correct catalogue of the library, arranged under such specific heads as were best calculated to assist the inquiries of all those who might resort to it for information. Various plans for this purpose were proposed and discussed: and it was finally determined that in order to insure uniformity of execution, the whole labour of compiling the new classed Catalogue, and of conducting it through the press, should be confided, though still under the superintendence of the Committee, to one person only; provided a proper person could be found who was fully competent to so arduous a task, and also willing to undertake it. The Council have accordingly engaged Mr. Panizzi, of the British Museum, a gentleman of great literary attainments, and conversant with that kind of labour, to undertake

this charge ; and have no doubt that he will accomplish it to the full satisfaction of the Fellows of the Society at large, to whom the possession of such a classed Catalogue as the one proposed, will be advantageous in many ways, independently of its direct utility in reference to the employment of the library.

The whole of the sum at which the Arundel Manuscripts which have been exchanged for books, were valued, has now been received from the Trustees of the British Museum, and the account with them is thereby closed.

The Council have also directed the printing of an edition of the Abstracts made by the Secretaries and entered on the Journal Book of the Society, of such papers as have been read to the Society and ordered for publication in their Transactions, from the year 1800 inclusive, to the present time. They conceive that a collection of these Abstracts, which possess in themselves much intrinsic value, will form an useful sequel to the Abridgement of the Philosophical Transactions of which the public is already in possession, but which does not extend to a later period than the end of the last century. This work will form two thick octavo volumes, one of which is now completed and ready for delivery to subscribers. The proof sheets, at the desire of the Council, were read over by Mr. Lubbock and Mr. Children, and no alterations were made except for the correction of errors obviously arising from inaccurate transcription. The Council have also directed a general Index to be made of the contents of the Transactions from the year 1821 to 1830 inclusive.

Documents relating to the periods and heights of the Tides having been furnished to the Society, at the request of the Council, by favour of the Lords Commissioners of the Admiralty, who have obligingly ordered these returns to be made from the principal sea-ports of England, a Committee has been appointed for the purpose of examining and digesting them, and for printing such of the observations or results as they may deem useful.

The Committee for conducting the Meteorological Observations have been anxious to arrange a plan for insuring their accuracy, and increasing their utility. They find that standard instruments are much wanted for furnishing correct data in this department of science. This deficiency they are endeavouring to supply ; and have in particular been promised the kind assistance of Mr. Daniell and Dr. Prout in superintending the construction of a standard barometer of superior accuracy, on the indications of which they expect that the utmost reliance may be placed.

The telescope, which the Council, with the advice of a Committee, had requested Mr. Barlow to construct as an experiment, on the principles stated by him in his paper in the Philosophical Transactions, is now completed, and will soon be ready for trial.

The Council have awarded one of the Copley Medals to Mr. Faraday, for his discovery of Magneto-Electricity, as explained by him in his Experimental Researches in Electricity, published in the Philosophical Transactions for the present year.

Oersted's important discovery of the influence of voltaic electricity

on a magnetic needle, was rapidly succeeded by a series of minor ones, all tending to establish the existence of an intimate connexion between magnetism and electricity. The evidence, however, of that connexion, resting, as it did, on the mutual influence of magnets and wires in which electric currents passed, and in the development or induction of magnetism by electricity, was positive on one side only; to render it conclusive, it remained to be shown that electricity could be excited by magnetism: and this, by a series of experiments as simple as they are beautiful, founded on a train of correct reasoning, Mr. Faraday has happily accomplished.

Although the Council consider that the discovery of magneto-electricity fully entitles its author to the Copley Medal, they by no means limit the value of the papers in which it is detailed to this discovery, however important. Even the preliminary facts, as they fully establish volta-electric induction, had they at the time led no further, would have been of the greatest value; but they were in hands in which they could not long remain barren, and the expectation they held out of important results was soon realized. Beyond the details of the discovery, the author rapidly but clearly establishes the laws according to which electric currents are excited by a magnet. He satisfactorily applies these laws to the explanation of a very interesting class of phenomena previously observed, namely, the reciprocal action of magnets and metals during rotation. He at the same time establishes an important distinction among bodies which had long been considered as associated by phenomena common to them all; and gives indisputable evidence of electric action due to terrestrial magnetism alone. An important addition is thus made to the facts which have long been accumulating for the solution of that most interesting problem, the magnetism of the earth.

The Council have awarded another Copley Medal to M. Poisson, for his work entitled *Nouvelle Théorie de l'Action Capillaire*. In this work a great variety of problems are solved relative to molecular attraction, some of which had not before been attempted; but the most remarkable feature of the work is, the conclusion which the author draws, namely, that the elevation and depression of liquids in capillary tubes are essentially dependent on the rapid variation of density which takes place at the surface of the fluid, and without which, according to the author, that surface would continue plane; this is at variance with the theory given in the *Mécanique Céleste*, although indeed Laplace notices this change of density at the surface, as a necessary consequence of the action of the molecules upon each other (Supp., x. livre, p. 74.) The theorems and expressions of M. Poisson do not differ in form from those of the *Mécanique Céleste*; but the constants which are involved in these equations are not expressed by the same definite integrals. No difference ensues in the consequences which are deducible from them, because the law of molecular attraction being unknown, it is impossible to arrive at the value of these constants *à priori*, or otherwise than by observation.

M. Poisson has calculated the vertical and horizontal pressures upon a solid body plunged in a fluid: the value of the latter does not

agree with that given in the *Mécanique Céleste*. According to the expression of Laplace the body might take a motion of translation : to this objections were formerly made by Dr. Young, and it will be noticed with interest that these objections are now confirmed by M. Poisson. The Council have awarded the Medal to the author, in order to testify the high sense which they entertain of the importance of the researches contained in the work in question.

The Society next proceeded to the election of the Council and Officers for the ensuing year, when the following was declared to be the list:—

President: His Royal Highness the Duke of Sussex, K.G.—*Treasurer*: John William Lubbock, Esq. M.A.—*Secretaries*: Peter Mark Roget, M.D., John George Children, Esq.—*Foreign Secretary*: Charles König, Esq.

Other Members of the Council: Francis Baily, Esq.; Captain Francis Beaufort, R.N.; Mark Isambard Brunel, Esq.; Rev. William Buckland, D.D.; Samuel Hunter Christie, Esq. M.A.; William Clift, Esq.; Rev. James Cumming, M.A.; Benjamin Gompertz, Esq.; Joseph Henry Green, Esq.; George Bellas Greenough, Esq.; William George Maton, M.D.; Roderick Impey Murchison, Esq.; William Hasledine Pepys, Esq.; Stephen Peter Rigaud, Esq. M.A.; Rev. Richard Sheepshanks, M.A.; Rev. William Whewell, M.A.

December 6, 1832.

WILLIAM GEORGE MATON, M.D., Vice-President, in the Chair.

Decimus Burton, Esq.; Charles Purton Cooper, Esq. LL.D.; and Edward Ayshford Sanford, Esq. M.P.; were elected Fellows of the Society.

December 13, 1832.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer, in the Chair.

A paper was read, entitled, "On the extensive atmosphere of Mars." In a Letter to His Royal Highness the President. By Sir James South, Knt. F.R.S.

In this paper the author gives an account of a further observation which corroborates the conclusion he had stated in a former communication "On the extensive atmosphere of Mars," namely, that no indication now existed of any atmosphere being attached to that planet. A star retained its light blue colour, and its full brilliancy and comparative steadiness till the very instant of its occultation by Mars. At its emersion it was seen nearly dichotomised. The author concludes, that either some physical change has occurred in the atmosphere of that planet, or that the observations of Cassini and of Roemer were inaccurate.

A paper was also read, entitled, "On the Law which connects the various Magneto-electric Phenomena lately discovered by Dr. Faraday." By the Rev. William Ritchie, LL.D. F.R.S. Professor of Natural and Experimental Philosophy in the Royal Institution of Great Britain, and Professor of Natural Philosophy and Astronomy in the University of London.

The general principle from which the author deduces the law in question, is that of the equality of action and reaction. The application of this principle to électro-magnetism, he thinks, may be thus expressed:—since a current of voltaic electricity can, in certain circumstances, induce magnetism, magnets will, in similar circumstances, induce similar voltaic currents. He gives an account of several experiments in confirmation of the universality of this law.

A paper was then read, entitled, "An Account of an extraordinary Meteor seen at Malvern, November 12, 1832." By W. Addiscn, Esq. F.L.S. Communicated by W. G. Maton, M.D. V.P.R.S.

The author beheld, from the Malvern Hills, a constant succession of meteors, of various degrees of magnitude and brilliancy. The smaller ones were like those commonly called shooting stars, and left behind them, for a moment, a train of pale yellowish light. Others were much more brilliant; and notwithstanding the bright moonshine threw a strong glare upon every object, they always commenced as a small luminous point, rapidly increasing in size and splendour, shooting with great swiftness over a considerable arc, and then, suddenly disappearing, left behind them a long train of very vivid white light, which slowly changed into a pale yellow. The author witnessed this scene for upwards of an hour, although it was still going on when he left it. At one time he counted forty-eight of these meteors during the interval of five minutes.

December 20, 1832.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

A paper was read, entitled, "On certain properties of Vapour." By the Rev. Dionysius Lardner, LL.D. F.R.S.

It has been generally supposed, that if a certain volume of aqueous vapour, contained in a vessel that was incapable of transmitting heat, were compressed by an exterior force into a space sufficiently small, a part of it would be restored to the liquid state. The author considers this assumption to be at variance with the doctrine of latent heat, and inconsistent with the results deduced from the experiments which have established that the absolute quantities of heat necessary to convert a given weight of water into steam, under all pressures, are sensibly equal. It follows, from this principle, that steam raised from water, under any pressure whatever, admits of indefinite compression and expansion, without returning to the liquid state. The effect of its compression will be to evolve heat and raise the temperature; that of its expansion, to absorb heat and lower the temperature: but in every state of density it will have exactly that tempera-

ture which it would have were it immediately raised from water under the pressure which it has acquired by compression or expansion. The only cause of the restoration of vapour to the liquid form is the abstraction of heat from it; and this cause will be equally operative, whatever may be the state of the vapour with respect to density: but compression alone, without such abstraction of redundant heat, can never convert any portion of vapour into a liquid. In accordance with these views, the author regards the permanent gases as vapours, containing a large quantity of redundant heat.

A paper was also read, entitled, "On the Secretion and Uses of the Bile." By B. Phillips, Esq. Communicated by W. G. Maton, M.D. V.P.R.S.

The object of the author of this paper is to establish the three following propositions; viz.

1°. That the principles of the bile pre-exist in the blood, and that the function of the liver is to separate from the blood a certain proportion of this material.

2°. That bile may be secreted as well from arterial as from venous blood.

3°. That chyle may be formed in the absence of bile.

In support of the first proposition the author adduces the analogy of other secretions, the suppression of which is followed by the appearance in the blood of the peculiar animal product which characterizes that secretion, as has been proved in the case of the urine by Prévost and Dumas, and afterwards by Vauquelin, Serullas, and Magendie. The author has confirmed the conclusion to which these physiologists have arrived, by some experiments of his own, in which, instead of extirpating the kidneys, he contented himself with tying the venal vessels. He relates two cases in which the vena portæ and hepatic artery were tied, and bile was found both in the urine and the blood.

The author, after quoting several authorities in support of his second proposition, that the liver can secrete bile, although the vena portæ be obstructed, relates two experiments which he made on dogs, by tying the vena portæ at the part before it arrives at the transverse fissure of the liver: in both cases that organ continued to secrete bile, though the quantity was small. In another dog, he tied the hepatic artery, with the effect of producing fatal peritonitis, but without any apparent change in the biliary secretion.

The arguments adduced by the author in favour of the opinion that chyle may be formed when no bile is present in the intestine, are derived from the accounts given by various authors of cases in which the ductus communis had been rendered impervious by the pressure of neighbouring tumours. In confirmation of this result, he made experiments on four dogs, and found chyle in the thoracic duct after he had tied the ductus communis close to the duodenum.

The author concludes, from these and other facts, that the secretion of bile is intended to serve some other purpose than that of contributing to the formation of chyle.

A paper was communicated to the Society, entitled, "Experimental Researches on Electricity, Third Series," by Michael Faraday, Esq. D.C.L. F.R.S. M.R.I., the reading of which was deferred to the next Meeting.

The Society then adjourned over the Christmas Vacation, to meet again on the 10th of January.

January 10, 1833.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer, in the Chair.

The reading of Mr. Faraday's paper, communicated at the last Meeting, and entitled, "Experimental Researches on Electricity, Third Series," was commenced.

January 17, 1833.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

The reading of Mr. Faraday's paper was resumed and concluded.

The object of the inquiries of which an account is given in the present paper, is to establish the identity of the electricities derived from different sources. The author was induced to investigate this subject, because doubts have been frequently expressed as to the accuracy of some experiments from which the identity of common and voltaic electricities is inferred: and distinctions have been drawn between them, as if they were different forms and modifications of one common power. In order to examine the question in all its bearings, he arranges the phenomena under two general heads; namely, those arising from electricity in a state of equilibrium, or *tension*, as it has been called; and those which are the consequence of its *motion*, when that equilibrium has been destroyed. The visible effects of electricity of tension are attractions or repulsions at sensible distances; those of electricity in motion are the evolution of heat, the production of magnetism, chemical decompositions, physiological changes, and, lastly, the evolution of light in the form of a spark. The author proves, by experiments, that every one of these phenomena takes place from the operation either of ordinary or of voltaic electricity; the degree in which they are produced depending on the different circumstances of quantity, of intensity, and of velocity, attendant on the different modes in which electricity has been excited and supplied. Thus no difference was found to exist in the mode in which a Leyden battery charged with ordinary electricity, and a voltaic battery, were discharged, when the comparison was made by means of fine points, nicely arranged and approximated, either through air of the ordinary temperature, or through heated air, such as the flame of a spirit-lamp, interposed between the points.

By the term *current*, the author designates any progressive change, of whatever nature it may be, in the electric state, whether consisting

in the motion of one electric fluid in a particular direction, or of two fluids in contrary directions : and by the term *arrangement*, he understands a local adjustment of particles, or fluids, or forces, not progressive.

By *ordinary electricity*, he understands that which can be obtained from the common electrical machine, or from the atmosphere, or by pressure, or cleavage of crystals, or similar mechanical operations ; its character being that of great intensity, and the exertion of attractive and repulsive forces, not merely at small but also at considerable distances. The parallel between voltaic and ordinary electricity is then pursued by the production of evidence that those attractions and repulsions, which were thought to characterize the latter, are exhibited also by the former ; and that, on the other hand, ordinary electricity, when in motion, gives rise to an increase of temperature, to magnetic phenomena, to chemical decompositions, to physiological impressions, and to luminous appearances, precisely of the same kind as those which had been supposed to be the peculiar effects of voltaic electricity. The experiments of Mr. Colladon, which seemed to show that a stream of common electricity has power to produce the deflexion of a magnet,—a conclusion which has hitherto rested on the single testimony of that experimentalist,—have been repeated and extended by Mr. Faraday, who completely confirms their accuracy, and the truth of the result that had been obtained from them. The author succeeded in making common electricity assume more of the characters of voltaic electricity, by availing himself of the retarding power of bad conductors interposed in the electric circuit. In this way he easily succeeded in obtaining the same decisive evidence of chemical action by common electricity as Dr. Wollaston had done in his experiment. But Mr. Faraday considers the experiment in which water is decomposed by this power, as affording no proof of electro-chemical agency ; because, as Dr. Wollaston had pointed out, both oxygen and hydrogen are evolved at each of the points of the interrupted circuit, and not separately at the respective poles. The author regards the amount of electro-chemical decomposition as being proportional, not to the *intensity*, but to the *quantity* of electricity transmitted. It is not effected by electricity passed from the machine in sparks, although these tend to decompose water into its constituent elements. Some experiments of Bonijol on the decomposition of water by atmospherical electricity, are commented on by the author, who considers them as analogous to the experiment of Dr. Wollaston already referred to. Mr. Faraday also makes some remarks upon Mr. Barry's paper in the Philosophical Transactions for 1831, and suggests doubts of the soundness of the inferences he draws from his experiments.

The author then proceeds to examine the electrical phenomena elicited by magneto-electricity, and shows that, as far as they have been observed, they coincide with those of voltaic electricity, and, consequently, are referrible to the same agency. The only effects that have not been yet obtained are chemical decompositions. The quantities of thermo-electricity that can be elicited in ordinary cases are

too small to produce any effects but those of magnetism, and also muscular contractions in the limbs of frogs. The animal electricity of the torpedo produces most of the effects of voltaic electricity, excepting the evolution of heat and light. The general conclusion deduced by the author from these researches is, that electricity, whatever be its source, is perfectly identical in its nature.

In the concluding chapter of the present paper, the author endeavours to establish some relation by measure between common and voltaic electricity. He shows, by experiment, that whenever the same *absolute quantity* of electricity, whatever be its *intensity*, passes through the galvanometer, the deflecting force exerted upon the magnetic needle is invariably the same. Hence this deflecting force may be taken as the measure of the absolute quantity of transmitted electricity; a principle which establishes the value of the galvanometer as an instrument of measurement in all cases of electricity in motion. The power of chemical decomposition he finds to be also directly as the quantity of transmitted electricity.

January 24, 1833.

The Rev. WILLIAM BUCKLAND, D.D., Vice-President, in the Chair.

A paper was read, entitled, "Magnetical Experiments, made principally in the South of Europe and Asia Minor, during the years 1827 and 1832." By the Rev. George Fisher, M.A. F.R.S.

This paper is divided into five sections. The first gives an account of a series of experiments made with a view to determine the relative intensities of the forces soliciting a horizontal magnetic needle, and also the forces in the direction of the dipping needle, at London, Lisbon, and Gibraltar; premising a minute description of the apparatus employed, and a circumstantial statement of the methods used for conducting the investigation.

The second section gives the details and results of similar experiments made at London, Malta, Syracuse, Catania, Messina, Naples, Baia, Constantinople, Egina, and Athens; and also on the plain of Troy, and at Vourla in Asia Minor.

The third section contains an account of experiments on the diurnal variation in the intensity of the magnetic force soliciting a horizontal needle in the island of Malta.

In the fourth section, experiments are related on the diurnal variation of the magnetic needle suspended horizontally at Malta.

The fifth section is occupied by an account of the results of similar experiments made on the bases and edges of the craters of Vesuvius and Ætna; and also on Gibraltar rock, and the neutral ground below: from which it appears, that the forces soliciting both the horizontal needle and that in the position of the dip, were considerably greater on the elevated than on the lower situations.

From the whole of the observations made in different parts of the Mediterranean, and contained in this paper, it appears that great

irregularity exists in the numerical results ; but whether these arise from irregularities in the distribution of the terrestrial magnetism, or from any active agency of a volcanic nature, or other cause, the author does not venture to decide.

January 31, 1833.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer,
in the Chair.

A paper was read, entitled, "An experimental Inquiry into the Treatment of Tic Douloureux." By W. R. Whatton, Esq. F.S.A. M.R.C.S. Communicated by P. M. Roget, M.D. Sec. R.S.

The author, after giving a brief account of the history of neuralgia facialis, and of the opinions that have been entertained of its nature, states the results of his trials of morphia applied to the skin, when denuded of cuticle by the previous application of a blister. The form he usually employs is that of a cerate, composed of eight grains of the acetate of morphia, finely powdered, to an ounce of simple ointment or lard, one dram of which is applied every eight hours. After a few weeks the proportion of the acetate is doubled, and occasionally, in very severe cases, a cerate, containing twenty or twenty-four grains in the ounce, was used. He relates a number of cases in which this treatment was perfectly successful in curing the disease, even when it had been of long standing, and had resisted every other mode of treatment.

February 7, 1833.

WILLIAM GEORGE MATON, M.D., Vice-President, in the Chair.

The Very Rev. George Chandler, D.D., Dean of Chichester ; Woronzow Greig, Esq. M.A. ; and the Rev. Frederick Nolan, LL.D. ; were elected Fellows of the Society.

A paper was read, entitled, "On the relation which subsists between the Nervous and Muscular Systems in the more perfect Animals, and the nature of the Influence by which it is maintained." By A. P. W. Philip, M.D., F.R.S. L. & E.

The author, after referring to his former papers which have at different times been read to the Royal Society, and published in their Transactions, is led to view the brain and spinal marrow as the only active parts of the nervous system ; the nerves, whether belonging to the class of cerebral or ganglionic, together with their plexuses and ganglions, serving only as the means of conveying and combining the various parts of the former organs, and therefore being passive with reference to their functions. This view of the subject is directly opposed to that which has been adopted by many physiologists, who consider these ganglions as the sources, and not the mere vehicles, of nervous influence. In order to determine this point, the author made the following experiment on an animal that had been pithed

so as to destroy its sensibility, while the action of the heart continued. Under these circumstances, he applied mechanical irritation, and also various chemical agents, to the ganglions and plexuses of the ganglionic nerves, and found that the heart continued to beat with the same regularity as before, and with the same frequency of pulsation. From these and other observations, the author concludes that the ganglionic system of nerves, with their plexuses and ganglions, performs the office of combining the influence of every part of the brain and spinal marrow, and of bestowing it on the muscles of involuntary motion, these muscles being subservient to those functions of life which require that combined influence; that the manner in which the influence of these organs affects the muscular fibre is not essentially different from that of other stimulants and sedatives; and that this influence is not an agent peculiar to the nervous system, but is capable of existing elsewhere, and is consequently not a vital power, properly so called; a conclusion which appears to him to be confirmed from the circumstance that galvanism is capable of performing all its functions. Hence he infers that the brain and spinal marrow, far from bestowing on the muscular fibre its peculiar power, only supplies an inanimate agent, which, like all other such agents, capable of affecting it, acts on it either as a stimulant or sedative, according to the degree in which it is applied, and is identical with the galvanic influence.

February 14, 1833.

The Rev. WILLIAM BUCKLAND, D.D., Vice-President, in the Chair.

A paper was read, entitled, "On the Existence of four distinct Hearts, having regular Pulsations, connected with the Lymphatic System, in certain Amphibious Animals." By John Müller, M.D., Professor of Physiology in the University of Bonn. Communicated by Leonard Horner, Esq., F.R.S.

The author had long ago observed, that, in frogs, there exists, immediately under the skin, large spaces containing lymph, whence it can be readily collected by making incisions through the skin. These receptacles for lymph are larger in the frog than in the other amphibia: but all the animals of this class appear, from the observations of the author, to be also provided with remarkable pulsating organs, which propel the lymph in the lymphatic vessels, in the same way as the heart propels the blood circulating in the arterial system. In the frog, two of these lymphatic hearts are situated behind the joint of the hip, and immediately underneath the skin. Their contractions are performed with regularity, and may be seen through the skin; but they are not synchronous either with the motions of the heart, or with those of the lungs, and they continue after the removal of the heart, and even after the dismemberment of the animal. The pulsations of these two organs on the right and left side are not performed at the same time, but often alternate at irregular intervals.

The author proceeds to trace the connexions of these cavities with the lymphatic vessels in the neighbourhood, and with one another: and it appears from his researches, that the lymph of the hinder extremities, as well as that of the posterior part of the abdomen, is conveyed by means of these hearts into the trunk of the crural veins. He also gives a description of the posterior part of the venous system of the frog, noticing particularly the large transverse anastomosis between the sciatic and the crural veins, which joins the anterior median vein of the abdomen, and conducts the blood partly into the vena portæ, and partly into the renal veins.

Professor Müller has likewise discovered two anterior lymphatic hearts in the frog; a discovery to which he was led by some observations of Dr. Marshall Hall, who stated that he had seen in that animal an artery pulsate after the removal of the heart. These anterior lymphatic hearts lie on each side upon the great transverse process of the third vertebra, immediately under the posterior end of the scapula, and they are nearly as large as the posterior hearts. They receive the lymph of the anterior parts of the body, and probably also that of the intestinal canal, in order to transmit it into contiguous veins, which pour their contents into the jugular vein. The author has discovered similar organs in the toad, the salamander, and the green lizard; and is of opinion that they exist in all the amphibia.

The following announcement was made from the Chair:—

“His Royal Highness the President has received from Professor Gauss the abstract of a paper read by him at the meeting of the Royal Society at Göttingen, on the 15th of December last, entitled ‘*Intensitas vis magnetica terrestris ad mensuram absolutam revocata.*’ Mr. Gauss’s views possessing considerable interest, His Royal Highness is desirous that they should be made known to the Fellows of the Royal Society; but as the original paper will not be printed for many months, and the abstract which appeared in the *Göttingische gelehrte Anzeigen* is in a language not generally understood in this country, His Royal Highness has requested your Foreign Secretary to translate it; and I am commanded to desire your Secretary to read the same to the present meeting.

“In deviating thus far from the usual routine of the business of the Royal Society, His Royal Highness is actuated by a wish to promote the reciprocal and early communication of new and important discoveries and views in science, between our own and the other Societies of Europe, devoted, like this, to ‘*the improvement of natural knowledge.*’

“Communications of this nature, however, cannot of course be admitted into your Transactions; but the publication, from time to time, of your Proceedings, affords a happy means of giving them general circulation; and thus the rapid propagation of much valuable information will be effected, which otherwise, if not absolutely lost to us, would, at least, long remain unknown to the British scientific public.”

The following is the abstract of Professor Gauss's Memoir :—

Of the three elements which determine the manifestation of terrestrial magnetism in a given place, viz. Declination, Inclination, and Intensity, the first soonest engaged the attention of philosophers, the second much later, and the third has only at a very recent period become an object of investigation and experiment. This progressive interest is chiefly to be accounted for by the circumstance, that while the variation of the compass offered the greatest interest, as applied to the purposes of navigation and geodesic operations, the dip was looked upon as more nearly allied to it than was the intensity of terrestrial magnetism. To the natural philosopher, those three elements are absolutely of the same import, inasmuch as our knowledge of the general system of terrestrial magnetism will ever remain imperfect, until an equal share of attention has been bestowed on its separate branches.

For the first light thrown upon this subject we are indebted to the Baron Humboldt, whose attention was particularly directed to it during all his travels, and who has furnished a considerable series of observations, from which the gradual increase of this intensity, from the magnetic equator of the earth towards the magnetic poles, has been deduced. Many observers have since followed the footsteps of that great naturalist; and almost every part of the world to which, in recent times, travellers have penetrated, has furnished its quota of materials, from which already Hansteen (to whom this branch of philosophical inquiry is under great obligation) has been enabled to attempt the construction of an iso-dynamical chart.

The mode adopted in all these observations consists in disturbing the equilibrium of one and the same magnetic needle in places the comparative intensity at which is to be determined, and in exactly measuring the duration of its oscillations. This duration is indeed, *cæteris paribus*, dependent on the magnitude of the arc; but in such a manner, that however small the arc becomes, it still approaches a determined limit, loosely called the duration, and to which, the arc of oscillation being known, the really observed duration may easily be reduced. The intensity of terrestrial magnetism is thus inversely proportional to the square of the duration of oscillation of the same needle, or directly so to the square of the number of oscillations in a given time; and the result relates to the whole force, or to the horizontal portion of it, according as the needle has been caused to vibrate, in the plane of the magnetic meridian, round a horizontal axis, or, in a horizontal plane, round a vertical axis.

It is evident that the admissibility of this method entirely rests on the assumption of the unchanged magnetic state of the needle employed. If a properly-magnetized and carefully-preserved needle of good hardened steel be made use of for the experiments, and these do not take up too long a space of time, the danger to be apprehended from such alteration may not, indeed, be considerable; and the observer may rest the more satisfied in this respect, if, on returning to the first place, he find the time of the vibration to be the same; but experience teaches us that this result cannot by any means be calculated

upon ; neither can it be denied, that in resorting to such a proof we are only reasoning in a circle. It was known indeed, long ago, that both the declination and inclination in the same place are far from being invariable; that both of them, in the course of time, undergo very considerable progressive variations, independently of those periodical ones by which the nicety of observation is affected in different seasons and parts of the day. It is, therefore, no matter of doubt that the intensity of terrestrial magnetism must likewise be subject to them ; indeed, the periodical diurnal variations are clearly perceptible in delicate observations. Hence, even if, after a considerable lapse of time, the same time of vibration is again observable in a given place, we are not, on that account, warranted in ascribing this circumstance to anything but a casual compensation of the variations which the intensity of the magnetism of the earth in that place, and the magnetic state of the needle itself, may have experienced during that interval. But even allowing the certainty of the comparative method to be only diminished to a certain degree, not entirely annulled, provided too long a space of time do not intervene, that mode, at all events, becomes entirely useless in cases where it is required to ascertain what changes the intensity of terrestrial magnetic force undergoes in a given place during a very long interval. This question, of considerable interest in a scientific point of view, must, therefore, remain unanswered until the merely comparative method shall be superseded by one which reduces the intensity of terrestrial magnetism to unities perfectly determined and manifest, and entirely independent of the individual nature of the needles employed in the experiments.

It is not difficult to lay down the theoretical principles on which such an independent method is to be founded. The time of oscillation of a given needle depends on three quantities ; namely, the intensity of the terrestrial magnetism, the static momentum of the free magnetism in the needle, and the momentum of the inertia of this needle. The last of them may readily be ascertained by suitable methods ; and thus, from the observed duration of the oscillation, is deduced, not the quantity of the intensity of the terrestrial magnetism, but the product of this quantity into the static momentum of the free magnetism in the needle. But it is impossible to separate these two factors from one another, unless observations of quite a different kind be superadded, that involve a different combination of them ; and this end is attained by the use of a second needle, which, in order to ascertain the ratio of these forces, is subjected both to the influence of the magnetism of the earth and to that of the first needle. These two effects do, indeed, partly depend on the magnetic state of the second needle ; but, by suitably conducting the experiments, the observer may eliminate that state, inasmuch as the *ratio* of both forces becomes the more independent of it, the greater the distance of the two needles from one another is assumed. Here, however, it is obviously necessary, at the same time, to consider the position relative to the magnetic meridian, of the magnetic axes of both needles, and of that of the straight line connecting their centres, as also the magnetic state of the first needle ; all which cannot be subjected to

computation unless we know the law of the force exerted on each other by two elements of free magnetism, or, in other words, with which, according as they are of the same or different denominations, they repel or attract each other. Tobias Mayer had already conjectured this law to be the same with that of general gravitation, i. e. that the force is in the inverse ratio of the square of the distance. Coulomb and Hansteen have endeavoured experimentally to confirm this conjecture; and the fact is now completely established by the experiments detailed in Professor Gauss's forthcoming memoir. This law, however, only relates to the elementary effect; for the computation of the total effect of a magnetic body on another, as soon as the nature of the distribution of free magnetism in these bodies is accurately known, becomes a problem purely mathematical, and consequently remains dependent on their casual individual nature; but the greater the distance, the less the influence of this individuality becomes; and if the distance be very great, we may, *cæteris paribus*, assume (as indeed follows from the above principle,) the total effect to be inversely proportional to the cube of the distance. The product of this cube into the fraction which expresses the ratio of the effect of the first needle, and of the terrestrial magnetism on the second needle, will therefore, as the distances continually increase, tend to a determined limit. A proper combination of observations at several judiciously selected distances will, being mathematically treated, make us acquainted with that limit, from which may be deduced the *ratio* of those two quantities the product of which was derived from the observed times of vibration. The combination of both results will then obviously give those two quantities themselves.

The experiments for comparing the effects of the magnetism of the earth, and of the first needle on the second, suspended by a thread, may be conducted in two different ways; inasmuch as the latter may be observed either in a state of motion or of rest. The former is best effected by placing the first needle in the magnetic meridian of the second, whereby the time of a vibration of the latter is either increased or diminished, according as poles of the same or of different names are opposed to each other. The comparison of the time of vibration thus changed, with that occasioned by terrestrial magnetism alone, or rather, the comparison of an increased with a diminished one (under opposite directions of the first needle), will then readily lead to the ratio sought. The second mode is that of placing the first needle in such a manner that the direction of its influence on the second makes an angle with the magnetic terrestrial meridian; when the angle of deviation from the meridian, in a state of equilibrium, will equally lead to the knowledge of the ratio sought. And here, too, it is more advantageous to compare with each other two opposite deviations, under opposite positions of the first needle. The most advantageous position of this needle is along a straight line drawn through the middle of the second and perpendicular to the magnetic meridian. The first mode agrees upon the whole with that proposed some years ago by Poisson; but the experiments, as far as we have any record of them, made by some natural philosophers with a view to apply that mode, have either

entirely failed, or their results can at best be considered only as imperfect approximations.

Professor Gauss, who has made frequent trials of both those modes of proceeding, is satisfied that the second is, on many accounts, far preferable to the first.

The real difficulty consists in this, that other elements depending on the individual nature of the needles, enter, as well as the value of the limit, into the influences observed. That effect is represented by a series which proceeds by the negative powers of the distance, beginning from the third; where, however, the following terms become more considerable as the distance is smaller. Now those following terms are to be eliminated by means of several observations; but a slight acquaintance with the theory of elimination easily convinces us that unavoidable errors of observation will never fail to endanger the exactness of the results, as the number of co-efficients to be eliminated is greater; so that their number need not be very considerable to render the results of computation entirely useless. No precision, therefore, in the results can be expected, unless such considerable distances are employed as will make the series rapidly converge, and a few terms of it suffice. But in this case the effects themselves are too small to be determined with exactness by our present means of observation; and thus the ill success of the experiments hitherto made is readily explained.

However easy, therefore, in theory the methods of reducing the intensity of terrestrial magnetism to absolute unities may appear, yet their application will ever remain precarious until magnetic observations have attained to a much higher degree of precision than they have hitherto possessed. It is with this view that Professor Gauss has followed up several ideas long ago entertained by him relative to the improvement of our means of observing; confidently expecting that magnetic observations will, ere long, be carried to a degree of perfection nearly, if not altogether, equal to that of the most delicate astronomical observations. The expectation has been answered by the result. Two apparatus fitted up in the observatory of Göttingen, and which have been employed for making the observations, of which several are given in his memoir, leave nothing to desire but a suitable locality completely secured from the influence of iron and currents of air.

The following short abstract from the detailed description of the two apparatus and their effect, given in the memoir itself, will no doubt be acceptable to naturalists interested in this kind of research.

Professor Gauss has generally employed needles (if prismatic bars of such strength may be designated by that name) of nearly a foot in length, weighing each about one pound. They are suspended by an untwisted thread of $2\frac{1}{2}$ feet in length, composed of thirty-two threads of raw silk, and thus able to carry even double that weight without breaking. The upper end of the thread is tortile, and the degree of torsion is measured by means of a divided circle. To the south or the north end of the needle (according as the locality renders either the one or the other more convenient), a plane mirror is fixed, the sur-

face of which, by means of two adjusting screws, may be placed perpendicular to the axis of the needle ; but scrupulous attention need not be paid to this adjustment, as any deviation may most exactly be measured by the observations themselves, and taken into account as errors in collimation. The needle thus balanced is enclosed in a wooden cylindrical box, which, besides the small aperture in the lid for the passage of the thread, has a larger one in the side, which is rather higher and wider than the mirror already mentioned.

Opposite to the mirror, a theodolite is placed, the vertical axis of which is in the same magnetic meridian with the thread of suspension, and at a distance from it of about sixteen Parisian feet. The optical axis of the telescope is placed rather higher than the needle, and inclined in the vertical plane of the magnetic meridian, so as to be directed towards the centre of the mirror on the needle.

To the stand of the theodolite is fixed a horizontal scale of four feet in length, divided into single millimetres : it makes a right angle with the magnetic meridian. That point of the scale which is situated in the same vertical plane with the optical axis of the telescope, and which, for the sake of brevity, may be denominated the zero point, is marked out by a fine thread of gold depending from the middle of the object-glass, and charged with a weight. The scale is fixed at such a height that the image of a portion of it is seen in the mirror through the telescope, the eye-glass of which is adjusted accordingly. At the opposite side from the needle, in the same vertical plane, and at a distance from the telescope equal to that of the image, a mark is fixed, serving every instant to ascertain the unchanged position of the theodolite.

It is obvious, that if all these conditions be fulfilled, the image of the zero point on the scale will appear exactly on the optical axis of the telescope, and that, so far as an object of known azimuth is visible at the place of the theodolite, we may, by means of this instrument, immediately find the absolute magnetic declination. If, on the other hand, those conditions are only partially fulfilled, then, generally speaking, the image, not of the zero point, but that of another point of the scale, will appear on the optical axis ; and if the horizontal distance of the scale from the mirror have been measured with exactness, it will be easy to reduce the amount of the divisions of the scale to the corresponding angle, and thus to correct the result first obtained. By turning the needle in the stirrup (so that the upper surface becomes the lower), the amount of the error of collimation of the mirror may be ascertained with great ease and precision. In both the apparatus, one part or division of the scale is equal to nearly twenty-two seconds ; an interval which even the least practised eye may easily subdivide into ten parts.

By this mode of operating, therefore, the direction of the needle and its variations are determined with the greatest possible precision. It is by no means necessary always to wait till it is at rest ; as the two elongations to the right and the left may be observed with great accuracy, and their combination, properly managed, will indicate the corresponding point of rest with equal precision. During the antemeri-

dional hours, when the daily variation is most rapid, this may be followed almost from one minute of time to the other.

Of equal importance is this mode of proceeding for observing the duration of the vibrations. The passage of the vertical thread in the telescope before a fixed point of the scale (properly speaking, the reverse is the case), may, even if the whole deviation only amount to a few minutes, be observed with such a degree of precision as never to leave any uncertainty amounting to the tenth of a second in time. The considerable duration of a vibration (about 14 seconds in the most intensely magnetized needles), and the slow degrees by which the arc decreases, are productive of other important advantages: only a few vibrations are required to enable us to determine the time of one vibration with such accuracy, that, though the needle be left to itself for one or even several hours, no doubt will remain on the mind of the observer as to the number of oscillations performed during the interval of his absence. We may commence with vibrations so small (such, for instance, as those with which we generally leave off,) that the reduction to infinitely small vibrations becomes almost imperceptible; and yet, after an interval of six and more hours, the vibrations are still found sufficiently great to admit of having their beginnings observed with all requisite precision.

In cases where anomalies still appear in the observations (which, however will prove so trifling, that with the common means they would have been altogether imperceptible,) they are solely to be ascribed to the current of air which, in the locality where the experiments were made, could not be altogether avoided. To remedy this inconvenience the aperture of the box might be closed by a plane glass; but none perfectly true was within the author's reach, neither could it have been made use of without an inconvenient loss of light.

To the enumerated advantages of this method another may be added, which is, that the observer constantly remains at a great distance from the needle, while in the old mode of proceeding his proximity to it was unavoidable; so that, even if enclosed in a glazed case, it was exposed to the disturbing influence which might be exerted upon it by the warmth of the body, or that of the lamp, by the iron or even the brass which the experimenter might happen to carry about him.

The advantages of stout heavy needles over those of diminutive size, which have been made use of for most magnetical observations, particularly those relating to the time of vibration, are dwelt upon by Professor Gauss; he has since successfully employed one weighing upwards of two pounds, and expresses his conviction, that if needles of from four to six pounds in weight were used, on which slight currents of air would cease to exert any perceptible influence, magnetic observations might attain an exactness and precision unsurpassed by the most delicate astronomical observations. Much stronger threads would indeed be required for suspension, the torsion of which would produce greater reaction; but whatever the strength of the thread may be, the force of torsion must always, and may without any difficulty, be taken into account with the greatest exactness.

The two apparatus may likewise be made use of for another purpose, which, though not immediately connected with the principal subject of the memoir, may still be adverted to in this place. They are the most sensible and convenient galvanometers both for the strongest and weakest energies of the galvanic current. To measure the strongest, it is only required to bring the conducting wire single, and at a considerable distance (at least several feet), into the magnetic meridian below or above the needle; for very weak energies a multiplier is wound round the box containing the needle. Some of the experiments were made with a multiplier of 68 circumvolutions, producing a length of wire equal to 300 feet. No pair of large plates is requisite; a pair of small buttons, or even simply the ends of two different metallic wires dipped in acidulated water, produce a current indicated by the movement of the image along many hundred parts of the scale; but on using a pair of plates of very moderate dimensions, the image of the whole scale, as soon as the circuit is completed, is seen rapidly to dart through the field of vision of the telescope. It is obvious that by this method the measurement of galvanic forces may be conducted with a degree of ease and precision unattainable by the hitherto employed laborious modes by means of observed times of vibration; and it is literally true that by it we are enabled to follow from second to second the gradual decrease of the intensity of a galvanic current, which, it is well known, is more rapid in the beginning. If, in addition, instead of the single, a double (astatic) needle is used, no degree of electro-magnetic energy will be found too small to admit of being still measured with the utmost precision. Here, therefore, a wide field is opened to the naturalist for most interesting investigation.

Not a small portion of this unpublished memoir of Prof. Gauss is taken up by the developement of the mathematical theory; and also by various methods peculiar to the author, such as the determination of the momentum of inertia of the vibrating needle, independently of the assumption of a regular figure; by his experiments with a view to establish the above-mentioned fundamental law for the magnetic effects; and, finally, by the details of the experiments to determine the value of the intensity of terrestrial magnetism, of which last the following may be given as the results, as far as they relate to the intensity of the horizontal part of that force.

I. May 21	.....	1.7820
II. May 24	.....	1.7694
III. June 4	.....	1.7713
IV. June 24—28	..	1.7625
V. July 23, 24	..	1.7826
VI. July 25, 26	..	1.7845
VII. Sept. 9	.....	1.7764
VIII. Sept. 18	.....	1.7821
IX. Sept. 27	.....	1.7965
X. Oct. 15	.....	1.7860

For unities, the millimetre, the milligramme, and the second in time

have been adopted. The manner in which the measurement of the intensity has been determined by them cannot here be specified: the numbers, however, remain the same, provided the unity of space, and that of weight (properly speaking, unity of masses), are changed in the same proportion. These experiments vary partly with regard to the greater or less degree of care with which they were conducted, partly with regard to the places in which they were made, and to the needles employed.

The experiments VII, VIII, IX, were in every respect performed with all the precision which the apparatus in the present state admits of, and the distances were measured with microscopic exactness. In experiments IV, V, VI, X, some operations have been performed with rather less care; and the three first experiments are still less perfect in this respect.

The needles employed in the first eight experiments were not indeed the same, but they were nearly alike in size and weight (the latter between 400 and 440 grammes); the principal needle in experiment X. weighs 1062 grammes; experiment IX. on the other hand is made, with a much smaller needle (weight 55 grammes), merely for the sake of ascertaining the degree of precision, which, all other precautionary means being alike, may be attained in using a needle of such small dimensions: the result of this experiment is therefore much less to be depended upon.

Experiments VII. to X. were made in one and the same place in the observatory; the preceding ones in other places in the same observatory, and in apartments of the author's dwelling-house. No perfectly pure results therefore could be derived from these latter experiments, inasmuch as the iron in those localities, and particularly in the observatory, becoming itself magnetic by the magnetism of the earth, would necessarily react upon the needle, and confound its influence with that of the terrestrial magnetism. Such places, indeed, were uniformly chosen in which neither fixed nor moveable masses of iron were near; nevertheless, even the more distant ones may not have been altogether without their effect upon the operations. However, on casting a look over the different results, it appears probable, that in no one of those localities, the modification of the terrestrial magnetism produced by extraneous influence exceeds the hundredth part of the whole. But results commensurate to the precision belonging to this mode can only be expected in a locality entirely free from the influence of iron.

In order to obtain the intensity of the *whole* force of the terrestrial magnetism, the numbers found are to be multiplied by the secant of the inclination. Mr. Gauss intends at a future period also to treat this element according to peculiar methods; in the mean time he merely mentions that on June the 23rd he has found $68^{\circ} 22' 52''$ with the inclinorium of the University collection of instruments,—a result which, as the observation was made in the observatory, and therefore not without the reach of local interference, may possibly require to be rectified by other observations.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1832-1833.

No. 12.

February 21, 1833.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

A paper was read, entitled, "On the Influence of the Sun's Rays on the Oscillations of the Magnetic Needle." By William Snow Harris, Esq. F.R.S. In a letter addressed to Samuel Hunter Christie, Esq. M.A. F.R.S.

The apparatus employed by the author in the inquiries of which he gives the results in the present paper, is very similar to that he has already described in his former communications to the Royal Society. It allowed of his carrying on a long series of experiments with freely suspended magnets, oscillating in a medium either rare or dense, and either in the sunshine or in the shade. The source of error incident to experiments in sunshine, made under an air-tight receiver, arise from the increased temperature, producing, both in the rare and in the dense medium, an irregular expansion, and a constant circulation of currents of air, which interfere with the equable movements of the bar—a condensation of vapour on the interior of the receiver—an expansion of the bar itself, by which its length, as a pendulum, becomes changed—and, lastly, a derangement of the original magnetic state of the bar. These disturbing causes he endeavoured to avoid by observing the oscillations, first in the shade, under a close receiver, and next when a beam of sunshine was thrown into the receiver by means of a plane mirror; in which case the heat was inconsiderable. When the bar had been allowed to return to its former temperature, similar experiments were repeated, after exhausting the receiver. The results of a series of experiments conducted in this manner are given in several tables: and the author concludes from them that the influence of the solar rays on a magnetic bar, oscillating in air, is to increase its apparent rate of oscillation; while in vacuo, that rate is diminished.

The author seeks for an explanation of these phenomena in certain changes effected in the surrounding medium. Comparative experiments were instituted on a bar of copper of the same dimensions as the magnetic bar employed in the former series. The author concludes from these inquiries, that the phenomena in question are independent both of the magnetic state of the bar, and also of the influence of solar light. He tried the effect of exposure of the bar to the intense light evolved by lime, acted upon by the influence of the oxy-hydrogen blowpipe; but with the same negative result.

An Appendix to the preceding paper was also read, entitled, "Remarks on Mr. Snow Harris's Communication," by S. H. Christie, Esq. M.A. F.R.S.; in which the latter gentleman, although he admits that Mr. Harris's experiments may explain some of the phenomena observed by Mr. Christie, yet he does not consider them as conclusive against the existence of the magnetic influence of the solar rays, and points out several circumstances in support of that opinion.

February 28, 1833.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

A paper was read, entitled, "A Relation of the case of Thomas Hardy Kirman, with remarks on Corpulence." By Thomas Joseph Pettigrew, Esq. F.R.S.

The subject of this communication, T. H. Kirman, was born at Barrow Mill, near Barton-upon-Humber, in Lincolnshire, on the 18th of April 1821. His father, who is a miller, is of middle stature, but inclined to corpulency; his mother tall and stout; and both perfectly healthy. Their son Thomas was not remarkable at the time of his birth for any peculiarity either in size or strength. He has enjoyed uniform health, excepting that when six years old he fractured his thigh, and was in consequence confined for five weeks to his bed; on rising from which, by an imprudent exertion, he injured his knee, and was obliged to lie upon a couch for five or six weeks longer. It was during this period of inactivity that he was first observed to increase much, both in bulk and height. This increase has since been progressive; and especially rapid during the last twelve months. At the present time, at which he is within two months of being twelve years old, he measures five feet one inch in height, and weighs one hundred and ninety-eight pounds. He measures round the chest $45\frac{1}{2}$ inches, round the abdomen 44 inches, round the pelvis $48\frac{1}{2}$ inches, round the thigh 27 inches, round the calf of the leg $18\frac{1}{2}$ inches, round the upper arm 13 inches, round the fore arm $11\frac{1}{2}$ inches, round the wrist 7 inches, and across the shoulders 19 inches.

The fat deposited is of firm consistence, and the muscular frame is strongly developed. His size occasions him at present but little inconvenience; his appetite and sleep are moderate; his habits and sports perfectly juvenile; and there is no appearance of puberty. He has a brother and two sisters, who are all of the ordinary height and size.

This account is followed by remarks on the subject of corpulency. The author observes, that this habit of body is most frequently met with in marshy districts, and has an apparent relation with the humidity of the climate. It is much more prevalent in England than in France or the South of Europe. It may often be traced to hereditary predisposition, and is promoted by tranquillity and cheerfulness of mind, and equability of temper, by full living, the use of fermented liquors, and of certain articles of diet containing much nutritious

matter, and also by inaction of body, whether the result of natural indolence, or, as was originally the case in the present instance, of necessary confinement.

Various other circumstances are enumerated by the author as favouring the accumulation of fat; and various expedients pointed out for obviating this morbid tendency, founded on the principles of diminishing the supply of nutriment, of increasing the tone of the system, and stimulating it to greater activity.

The reading of a paper, entitled, "Experimental Determination of the Laws of Magneto-electric Induction in different masses of the same Metal, and of its Intensity in different Metals," by Samuel Hunter Christie, Esq. M.A. F.R.S., was commenced.

March 7, 1833.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer, in the Chair.

The reading of Mr. Christie's paper was resumed and concluded.

Mr. Faraday, in his valuable papers entitled "Experimental Researches in Electricity," has advanced the proposition, that "when metals of different kinds are equally subject, in every circumstance, to magneto-electric induction, they exhibit exactly equal powers with respect to the currents which either are formed or tend to form in them;" and "that the same is probably the case in all other substances." The author not being satisfied with the conclusiveness of the experiments adduced in support of this proposition,—in order to determine its correctness, subjected different metals directly to the same degree of magneto-electric excitation, in such a manner, that the currents excited in them should be in opposite directions (as was the case in Mr. Faraday's experiment), and also that these opposing currents should have the same facility of transmission; so that the difference of their intensities, if any existed, might admit of measurement. He then minutely describes the apparatus he contrived with this view, and which consisted of helices of copper and of iron wire, covered with silk, each making sixty-five turns, but in opposite directions, and crossing each other alternately, and surrounding a cylinder of soft iron, which was rendered magnetic by the application of the large magnet belonging to the Royal Society, which the Council had placed at his disposal while engaged in these researches. The result of the experiment showed that the force of the currents from the copper helix considerably exceeded that from the iron helix, and appeared to be even more than double. By a modification of the apparatus, he found that the intensities of the currents in the two wires were very accurately proportional to their conducting powers; and hence the uniformity of the results obtained by Mr. Faraday is easily explicable.

The next object of Mr. Christie was to determine the order of the

relative intensities and conducting power of several of the metals : but previously to engaging in this inquiry, he made a series of experiments, with a view of determining the law of intensities as depending upon the length and diameter of the wire through which the current is transmitted. For this purpose it was necessary to devise means of making and breaking the contact in as invariable a manner as possible. This he accomplished by letting the same weight fall from a constant height when the contact was to be broken, and suddenly relieving the cylinder of the tension caused by the same weight when the contact was to be formed. He ascertained that portions of wire connected with the one which formed the circuit, but not included in the circuit itself, had scarcely any influence on the intensity of the current. He then enters into various theoretical investigations as to the mode of deducing the absolute intensities of the currents in this mode of experimenting.

By comparing the intensity of the electricity in wires of one metal with that in wires of each of the others, by means of the arrangement described in the beginning of the paper, and taking a mean of the results, he found the relative intensities in the following metals to be, silver 1520, gold 1106, copper 1000, zinc 522, tin 253, platinum 240, iron 223, and lead 124. The author compared these results with those obtained by Davy, Becquerel, Professor Cumming, and Mr. Harris, and states what he considers may have been the causes of the differences.

The second object of the author's inquiry relates to the law of variation of the intensity of the electricity excited in wires of different diameters : for determining which he compares the effects of three different wires of which the diameters were in the proportion of 4, 2, and 1. The results occupy several tables : and the deduction from them, with regard to the law in question, is, that the intensity varies nearly as the square of the diameter : but several causes contribute to interfere with the accuracy of this determination, and to exhibit the power as a mean of 1.844 instead of 2 ; the principal of which is the action of the coils upon each other.

By other methods, in which two wires of different lengths and diameters are placed so as to oppose each other in their effects, the accuracy of the conclusion that this power is the square, was satisfactorily established. Hence he arrives at the general conclusion, that the intensity or conducting power varies as the mass or weight directly, and as the square of the length inversely.

A paper was then read, entitled, "Note on the Tides." By John William Lubbock, Esq. V.P. and Treasurer of the Royal Society.

This communication contains some interesting results which Mr. Lubbock has obtained from observations made at Plymouth, Portsmouth, and Sheerness, under the superintendence of the Masters attendant at those dockyards. Mr. Dessiou has, with extraordinary perseverance, just completed the discussion of about 6000 additional observations of the tides at the London Docks, with a view to found on a more certain basis the corrections of the moon's parallax and

declination. The results which he has obtained are utterly irreconcilable with the theory of Bernoulli, and therefore the tables computed upon that theory must be rejected as inaccurate.

A paper was also read, entitled, "On the Nature of Sleep." By A. P. W. Philip, M.D. F.R.S. L. & E.

The author intends the present paper as a continuation of his inquiries into the relations subsisting between the nervous and muscular systems, which form the subject of his former papers, but which would be incomplete without the consideration of their condition during sleep. With this view he proposes to determine the particular organs, on the condition of which this peculiar state of the system depends; the laws by which it is governed; and the influence it has upon other parts of the system. The necessity of intervals of repose applies only to those functions which are the medium of intercourse with the external world, and which are not directly concerned in the maintenance of life. The organs subservient to these two classes of functions may be viewed as in a great degree distinct from one another. The brain and spinal marrow constitute alone the active portions of the nervous system. The law of excitement, which regulates the parts connected with the sensorial functions, including sensation, volition, and other intellectual operations, and the actions of the voluntary muscles, is uniform excitement, followed by a proportional exhaustion; which, when occurring in such a degree as to suspend their usual functions, constitutes sleep; all degrees of exhaustion which do not extend beyond the parts connected with the sensorial functions being consistent with health. On the other hand, the law of excitement of those parts of the brain and spinal marrow which are associated with the vital nerves, and are subservient to the vital functions, is also uniform excitement; but it is only when this excitement is excessive that it is followed by any exhaustion; and no degree of this exhaustion is consistent with health. The law of excitement of the muscular fibre, with which both the vital and sensitive parts of the brain and spinal marrow are associated, namely, the muscles of respiration, is interrupted excitement, which, like the excitement of the vital parts of these organs, is, only when excessive, followed by any degree of exhaustion. The author conceives that the nature of the muscular fibre is everywhere the same; the apparent differences in the nature of the muscles of voluntary and involuntary motion depending on the differences of their functions, and on the circumstances in which they are placed: and he concludes, that, during sleep, the vital, partaking in no degree of the exhaustion of the sensitive system, appears to do so simply in consequence of the influence of the latter on the function of respiration, the only vital function in which these systems co-operate.

The author proceeds to make some observations on the cause of dreaming, the phenomena of which he conceives to be a natural consequence of the preceding proposition. In ordinary sleep, the sensitive parts of the brain, with which the powers of the mind are associated, are not in a state of such complete exhaustion as to preclude their being excited by slight causes of irritation, such as those which

accompany the internal processes going on in the system. The sensorium is the more sensible to the impressions made by these internal causes, inasmuch as all the avenues to external impressions are closed, and the mind is deprived of the control it exercises, during its waking hours, over the train of its thoughts, by the help of the perceptions derived from the senses, and the employment of words for detaining its ideas, and rendering them objects of steady attention, and subjects of comparison.

March 14, 1833.

The Rev. WILLIAM BUCKLAND, D.D., Vice-President, in the Chair.

A paper was read, entitled, "On the Figures obtained by strewing Sand on Vibrating Surfaces, commonly called Acoustic Figures." By Charles Wheatstone, Esq. Communicated by Michael Faraday, Esq. D.C.L. F.R.S.

The author, after adverting to the imperfect notice taken by Galileo and by Hooke of the phenomena which form the subject of this paper, ascribes to Chladni exclusively the merit of the discovery of the symmetrical figures exhibited by plates of regular form when made to sound. He proposes a notation, by means of two numbers separated by a vertical line, for expressing the figures resulting from the vibrations of square or rectangular plates. He gives a table of the relative sounds expressed both by their musical names and by the number of their vibrations, of all the modes of vibration of a square plate, as ascertained by the experiments of Chladni. He then proceeds to class and analyse the various phenomena observed under these circumstances, and shows that all the figures of these vibrating surfaces are the resultants of very simple modes of oscillation, occurring isochronously, and superposed upon one another; the resultant figure varying with the component modes of the vibration, the number of the superpositions, and the angles at which they are superposed. In the present paper, which forms the first part of his investigation, he confines himself to the figures of square and other rectangular plates.

The author finds that the principal results of the superposition of two similar modes of vibration are the following:—first, the points where the quiescent lines of each figure intersect each other remain quiescent points in the resultant figure; secondly, the quiescent lines of one figure are obliterated, when superposed, by the vibratory parts of the other; thirdly, new quiescent parts, which may be called points of compensation, are formed whenever the vibrations in opposite directions neutralize each other; and, lastly, at other points, the motion is as the sum of the concurring, or the differences of the opposing vibrations at these points. After considering various modes of binary superposition, the author examines the cases of four co-existing superpositions.

When the vibrations of the superposed modes are unequal in intensity, there is formed a figure intermediate between the perfect re-

sultant and one of its compounds. These figures the author denominates *imperfect resultants*.

In each series of transitions there are certain points which are invariable during all the changes: these are quiescent points, formed by the nodal lines of one figure intersecting those of the other, and the centres of vibration, where the maxima of positive or negative vibration agree in each component mode of vibration. The points of compensation are changeable. Transitional figures appear when the sides of the plate are nearly, but not exactly, equal.

The author next considers the figures obtained on square plates of wood and other substances, having different degrees of elasticity in different directions. He concludes this part of his paper by an account of some optical means of representing the figures noticed by Chladni.

March 21, 1833.

WILLIAM GEORGE MATON, M.D., Vice-President, in the Chair.

A paper was read, entitled, "An Account of two cases of inflammatory Tumour produced by a deposit of the Larva of a large Fly (*Æstrus humanus*) beneath the Cutis in the Human Subject; accompanied with Drawings of the Larva." By John Howship, Esq. Communicated by Charles Hatchett, Esq. F.R.S.

The first of these two cases is that of a soldier stationed on the banks of the Marawina river in Surinam, who had a large boil on the back, from which a maggot was pressed out. The second case, which occurred at Santa Anna, in the district of Maraquitá, in Columbia, is that of a carpenter, who had for some months a large boil on the scrotum, from which a living larva was extracted. A description of this larva, drawn up by Mr. Curtis, is given by the author, together with a drawing of the specimen. The author proposes giving to it the name of the *Æstrus humanus*.

The reading of a paper, entitled, "Experimental Researches in Electro-magnetism," by the Rev. William Ritchie, LL.D. F.R.S. was commenced.

March 28, 1833.

The Rev. JAMES CUMMING, M.A., Vice-President, in the Chair.

The reading of Dr. Ritchie's paper was resumed and concluded.

This communication consists of three parts. In the first part the author shows that the common deflecting galvanometer, in which the deflecting forces are assumed to be as the tangents of deflection, is founded on false principles, and consequently leads to erroneous results. The wire forming the coil is of considerable thickness, and therefore there is no fixed zero from which the deflections can be reckoned. The length of the coil, also, being generally short, occa-

sions another serious error, as the theoretical investigation is founded on the supposition of an indefinite length. In proof of the inaccuracy of the indications of the common deflecting galvanometer, the author took two elementary batteries, the plates of one being one inch square, and those of the other two inches. The tangents of the deflections of the needle (proper precautions having been taken for the equally free passage of all the electricity evolved in either case,) were very nearly as 1 to 2, though it is obvious that the real quantities of voltaic electricity were as 1 to 4. The author's torsion galvanometer gave the degrees of torsion nearly as 1 to 4. Other experiments led to similar conclusions.

The author then examines the laws which were supposed to connect the conducting power of a wire for electricity, with its length and diameter, and which, according to Professors Cumming and Barlow, varies directly as the diameter, and inversely as the square root of the length; but, according to MM. Becquerel and Pouillet, directly as the square of the diameter, and inversely as the length. He points out the false conclusions of M. Becquerel, and that he has, in fact, deduced the value of *two* unknown quantities from *one* equation; and that M. Pouillet having arrived at his through the fallacious indications of the common deflecting galvanometer, they are equally erroneous. The author then shows that the law pointed out by Cumming and Barlow is, in ordinary cases, nearest the truth; though, under certain circumstances, the limits of even that law may be passed. Hence, and from a series of experiments with the torsion galvanometer, he arrives at the unexpected conclusion, that there is no determinate law of conduction, either for the length or diameter of the wire, but that it must vary, in every case, with the size of the plates, and the energy of the acid solution used in exciting them. This conclusion the author shows to be in accordance with the views of conduction which he had previously published; namely, that there is no actual transfer of electricity, but that all the phenomena result from the definite arrangement of the electric fluid essentially belonging to the conducting wire.

The second part of this paper relates to certain properties of electro-magnets. No attempt seems to have been hitherto made to investigate the law which connects the lifting power of electro-magnets with their length. The author found, by experiments with two soft iron horse-shoe electro-magnets, to each of which the same short horse-shoe lifter was adapted, and the circuit of one four times that of the other, that their lifting powers were nearly inversely as the square root of their lengths. By increasing the strength of the battery with which they were connected, their lifting powers approached more nearly to a ratio of equality; by diminishing it, the ratio increased in favour of the shorter magnet. Hence the law in this case seems to be as indefinite as in that of common electric induction, and the relation of the powers to vary with the energy of the inducing voltaic influence. By another experiment, the author shows that all that is necessary in preparing a powerful electro-magnet is simply to roll a ribbon of copper about a short bar of soft iron, and to use a short horse-shoe lifter of soft iron. The quality of the iron has great influence on

the power of an electro-magnet ; and the author found that the worst part of a bar of the worst iron he could procure made by far the best.

A bar electro-magnet, four feet long, which scarcely retained any power when its connexion with the battery was broken, on being re-connected with it, in the *same* direction as before, was *rapidly* converted into a powerful magnet ; but after being removed, and its wires now connected with the *opposite* poles, it required a long time to convert it into a magnet of much inferior power ; as if the atoms of electricity, having been first put in motion in one direction, are afterwards more easily turned in that direction than in the contrary.

The author failed in his attempts to make a permanent horse-shoe magnet of tempered steel by the touch, with an electro-magnet : not the slightest trace of magnetism was communicated to the steel ; on the contrary, a previously magnetized horse-shoe magnet had its power completely destroyed by similar means.

Dr. Ritchie describes a method of making an electro-magnet revolve in a horizontal direction about its centre, by permanent magnets properly arranged. This method consists in changing the poles of the soft iron magnet the moment it passes the pole of the steel magnet, so that attraction is almost instantaneously changed into repulsion, and the motion rendered continuous.

In the third part the author describes a mode of obtaining a continuous current of electricity by the induction of common magnets. Any number of soft iron cylinders, having a coil of copper ribbon covered with thin tape wound round the middle, are fixed in such a manner to a revolving table, that they can be brought in rapid succession opposite to the poles of a permanent horse-shoe magnet : the soft iron cylinders are thus converted into temporary magnets. The copper ribbons are so connected, by means of wires soldered to their ends, with well amalgamated discs beneath, that their contact with them is successively made and broken, as often as the soft iron cylinders pass opposite the poles of the permanent magnet : and a delicate galvanometer is made to form part of the circuit. On putting the revolving table into rapid motion, an electric state is induced on the copper ribbon, and consequently on the continuous circuit, from the moment the magnet has begun to act on it till it has acquired its state of greatest magnetic power. The connexion being then broken, by the wire attached to the end of the copper ribbon leaving the amalgamated disc of copper beneath, the needle would return to its former position were it not prevented by the formation of a new current, from the next cylinder of iron coming within the action of the magnet ; and, by employing a greater number of magnets, the developement of the fresh current may be effected before the preceding one has been broken off, and the needle be thus made to show a steady deflection.

The author failed in all his attempts to effect chemical decomposition, even of the most easily decomposable compounds, by means of the nearly constant current of electricity produced by his present apparatus ; and previous to making a more powerful one, he wished to ascertain whether water be a conductor of electricity thus developed, or not. For this purpose a film of hot water, of more than fifty square inches, was made to form part of the circuit of the magneto-electric

battery; the whole being properly connected with an exceedingly delicate galvanometer. On making the apparatus revolve rapidly, not the slightest deflection of the needle was perceptible. Hence, if so large a surface of hot water be incapable of conducting as much electricity as would agitate the most delicate astatic needle, though the exciting cause was sufficient to make a wire revolve round a magnet, and overcome the resistance of the mercury through which it was dragged, it would require an enormous power of this kind to *decompose* water. The author, therefore, considers it unlikely that electricity induced by magnets will ever supply the place of the voltaic battery in effecting chemical decomposition; and he concludes by observing, that "as no increase of electro-magnetic power is gained by increasing the *decomposing* powers of a battery, and as action and reaction are equal, it appears improbable that we shall ever obtain high decomposing powers by any increase in magneto-electric induction."

A paper was then read, entitled, "Notice of the Remains of the recent Volcano in the Mediterranean." By John Davy, M.D. F.R.S. Assistant Inspector of Army Hospitals.

The author communicates an account given by Captain Swinburne, dated the 24th of August, of a dangerous shoal, in latitude $37^{\circ} 9' N.$ and longitude $12^{\circ} 43' E.$, consisting principally of black sand and stones, with a circular patch of rock, which has been left by the volcano that lately appeared in the Mediterranean. Captain Swinburne furnished the author with two specimens of the air which was seen rising from the site of the volcano, in small silver threads of bubbles. These were found, upon examination by chemical tests, to consist of between 9 and 10 parts of oxygenous to 79 or 80 of azotic gases.

The author adduces arguments in favour of the supposition that this air is disengaged from sea water at the bottom in contact with the loose and probably hot ashes and cinders composing the shoal, rather than that it arises from the extinct volcano. He is also disposed to extend this theory to the explanation of the gases disengaged from hot springs, which are generally found to consist of a mixture of oxygenous and azotic gases, the former being in less proportion than in atmospheric air, in consequence of its abstraction by oxidating processes from the air originally contained in these waters.

The Society then adjourned over the Easter vacation, to meet again on the 18th of April.

April 18, 1833.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

Thomas Botfield, Esq.; Sir William Burnett, Knt. K.C.H.; Major F. H. Shadwell Clerke, K.H.; Robert Adam Dundas, Esq.; the Rev. Augustus Page Saunders, M.A.; and Thomas Stephens Davies, Esq., were elected Fellows of the Society.

A paper was read, entitled, "On Improvements in the Instruments

and Methods employed in determining the Direction and Intensity of Terrestrial Magnetism." By Samuel Hunter Christie, Esq. M.A. F.R.S.

The tedious nature of the observations by which the direction and intensity of the terrestrial magnetic force are determined, and the uncertainty attending the results when obtained, have long been a subject of regret to all who are engaged in the investigation of the phenomena of terrestrial magnetism. Sensible of this, the author's attention has at different times been turned to the improvement of the instruments employed for these purposes; and in this communication he proposes methods by which he considers that these instruments might be so improved that the results should be obtained with greater facility and also with greater certainty. The uncertainty attending the results obtained with the dipping needle, as at present constructed, arises principally from the two sources, friction upon the axis, and the want of coincidence of the needle's centre of gravity with the axis of motion; the latter rendering necessary the inversion of its poles. The author suggests a method by which he considers that, probably, the friction may be diminished; but he has principally directed his attention to obviate the necessity of the inversion of the poles.

In order to remove the practical difficulty attending the adjustment of the centre of gravity to the axis of motion, an operation in which the artist rarely, if ever, completely succeeds, the author proposes to dispense with this condition; and shows how the dip may then be determined, without the necessity of inverting the poles of the needle, the position of its centre of gravity having been determined previously to its being magnetized. The advantages attending the method proposed by the author are not, however, restricted to the determination of the dip with greater accuracy and greater facility: a further and still greater advantage attending the use of a dipping needle on the principle he proposes, is, that a measure of the terrestrial magnetic intensity will be obtained by the same observations which give the dip; so that, by this means, the observations usually required for that purpose, and which are of the most tedious nature, will be avoided. To effect both these objects in the most convenient manner, he proposes that the needle should be so constructed that its centre of gravity should be out of the axis of motion, in a line perpendicular to that axis and to the axis of the needle. The requisite formulæ for determining the dip and the measure of the terrestrial intensity, in this case and also when the centre of gravity is in any other position, are investigated in the paper. Mayer had previously pointed out that the dip might be determined by means of a needle having its centre of gravity out of the axis of motion, and had given the formulæ requisite for that purpose. His object, however, does not appear to have been the same as our author's,—the avoiding in all cases that source of inaccuracy, the inversion of the poles of the needle,—but simply the determination of the dip, whether the centre of gravity of the needle were made to coincide with the centre of motion, or not: the determination of a measure of the terrestrial intensity, by such means, does not appear to have entered into his contemplation.

As another form in which the same principles might be advantageously applied, the author proposes that two needles, similar in all

respects, should be placed on the same axis; and points out how, by means of such a compound needle, both the dip and intensity might be determined by independent methods, so that the agreement of the results would afford a test of the accuracy of the adjustments and of the observations. He considers that the knife-edge support, which has recently been adapted to a dipping needle, would be peculiarly applicable to a needle of this construction. The sensibility of such a needle would be much greater than that of any hitherto constructed, and the utmost delicacy would be required in the adjustments; but if the needle were accurately constructed, and due care were taken in the magnetizing, and in making the adjustments and observations, the author expects that the dip and intensity would be determined to a degree of certainty hitherto unattained.

The advantages proposed to be derived from the use of a dipping needle on the principle described in this paper, are, that as the dip would be obtained without inversion of the poles, the results would be less liable to error than when that operation is necessary, and the observations would be made in less than half the time usually required; and that a measure of the intensity of terrestrial magnetism would be obtained from the same observations which give the dip, the intensity of the force being thus always determined by means of the same needle, and at the same instant as its direction.

April 25, 1833.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

A paper was read, entitled, "An Account of an extraordinary luminous appearance in the Heavens, seen at Athboy in Ireland, on the 21st of March, 1833." By the Right Honourable the Earl of Darnley. Communicated by John George Children, Esq. Sec. R.S.

The noble author's house is situated in lat. $53^{\circ} 37' N.$, long. $6^{\circ} 54' W.$ On the evening of the 21st of March last, at 9 P.M., a stream of luminous matter, reaching from the eastern to the western horizon, which it entered to the north of the constellation of Orion, was observed passing about midway between the Great Bear and Arcturus, and directly over the two principal stars of Gemini. The phenomenon was not accompanied by the usual flashings of an Aurora, but appeared to flow, when attentively observed, in a rapid stream from east to west, and varying in intensity in its course. His Lordship compares it to the stream from the pipe of an engine played over the head of a person standing under it, about the middle of its course.

The light was most brilliant at the eastern extremity of the arch, where it was about 1° wide, gradually increasing in width and diminishing in intensity as it approached the western extremity, where it may have occupied about 5° or 6° . Stars of the second and third magnitudes were distinctly visible through the arch, at least from the meridian to the western horizon; and though not apparently at a great elevation, light clouds occasionally seemed to pass between it

and the observer, obscuring its light. During twenty minutes that Lord Darnley observed the phenomenon, it seemed to proceed through its whole extent from north to south, its edges, which, when first observed, extended equally on either side of Castor and Pollux, having in that time entirely left the most northern of those stars. It had wholly disappeared before ten o'clock.

Lord Darnley did not see the beginning of the phenomenon; but was informed that it appeared at first like the moon rising, and gradually extended from the eastern to the opposite horizon. The reflection thrown on the earth was faint: the degree and colour of the light may be compared to that of a comet; of greater brilliancy, however, than any that has appeared in this century.

In a postscript, His Lordship states, that precisely the same appearance was observed at Castlereah, distant sixty miles; and, according to a Carlisle paper, somewhere in the North of England; the time of appearance in both cases corresponding very nearly with that of his own observation.

A paper was also read, entitled, "On the Magnetic Power of Soft Iron." By Mr. Francis Watkins. Communicated by Michael Faraday, Esq. D.C.L. F.R.S.

When free magnetism is developed by induction, and is not retained in that state by what has been termed the coercive force of hard steel, it has generally been considered that all the phenomena due to the existence of free magnetism cease on the removal of the inducing cause. The object of the present communication is to show that such is not the fact. From a variety of experiments described by the author, it appears that soft iron continued to exhibit strongly the attraction due to the development of magnetism long after the means by which the magnetism had been originally excited had ceased to act. In these experiments, bars of soft iron, in the form of a horse-shoe, had a single helix of copper wire wound round them, so that on the ends of the wire being brought into contact with the poles of a voltaic battery, the iron became an electro-magnet. With one of these horse-shoes, while the connexion between the ends of the helix and the poles of the battery existed, the soft iron, having a keeper applied to its poles, supported 125 pounds; it supported 56 pounds after that connexion had been broken, and continued to retain the power of supporting the same weight after an interval of several days, care having been taken not to disturb, during the time, the contact between the horse-shoe and its keeper. On this contact, however, being broken, nearly the whole attractive power appeared to be immediately lost. The author describes several instances of the same kind, particularly one in which the contact between the ends of the horse-shoe of soft iron and its keeper having been undisturbed during fifteen weeks, the attractive power continued undiminished. Although the interposition of a substance, such as mica or paper, between the ends of the horse-shoe and its keeper necessarily diminished the force of attraction, it did not appear to diminish the power of retaining that force. In a case where the electro-magnet of soft iron and its keeper were equal semi-circles, the author found, what may appear singular,

that the arrangement of the magnetism during the time that the electric current traversed the helix, appeared not to be the same as after the cessation of that current; in the one case similar, and in the other dissimilar, poles being opposed to each other at the opposite extremities of the two semi-circles.

Whether the magnetism was originally developed in the soft iron by means of an electric current passing round it, or by passing over its surface the poles of an electro-magnet, or those of a common magnet of hard steel, it appeared to possess the same power of retaining a large portion of the magnetism thus developed. The retention of the magnetism does not appear to depend upon the relative positions of the ends of the horse-shoe and the keeper remaining undisturbed, but on their contact remaining unbroken: for one keeper was substituted for another without diminution of this power; care being taken that the second should be in good contact with both ends of the horse-shoe before the complete removal of the first.

This power of soft iron to retain the magnetism developed in it was also shown by the action of the ends of the horse-shoe magnets upon a magnetized needle; by the attraction of iron filings; and by the evolution of the electric spark, by means of a suitable apparatus, on the sudden rupture of the contact between the keeper and the horse-shoe, when several days had intervened since the removal of the battery by which the magnetism had been originally developed.

The author's views on entering upon these experiments were, that the soft iron, with its keeper, resembled a closed voltaic circuit; but they have convinced him that the phenomenon of the permanency of the magnetism resolves itself into a case of complex induction, between the soft iron horse-shoe and the keeper.

May 2, 1833.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The Right Honourable the Earl of Darnley was elected a Fellow of the Society.

A paper was read, entitled, "Essay towards a first approximation to a Map of Cotidal Lines." By the Rev. William Whewell, M.A. F.R.S. Fellow of Trinity College Cambridge.

The general explanation of the phenomena of the tides originally given by Newton, although assented to by all subsequent philosophers, has never been pursued in all the details of which its results are susceptible, so as to show its bearing on the more special and local phenomena, to connect the actual tides of all the different parts of the world, and to account for their varieties and seeming anomalies. The first scientific attempt that was made to compare the developed theory with any extensive range of observations, was that of Daniel Bernouilli in 1740: the subject has since been pursued by Laplace and Bouvard, and still more recently by Mr. Lubbock. But

the comparison of contemporaneous tides has hitherto been unaccountably neglected : and to this particular branch of the subject the researches of the author are in this paper especially directed ; the principal object of his inquiry being to ascertain the position of what may be called *cotidal lines*, that is, lines drawn through all the adjacent parts of the ocean where it is high water at the same time ; as, for instance, at a particular hour on a given day. These lines may be considered as representing the summit or ridge of the tide wave existing at that time, and which advances progressively along the sea, bringing high water to every place where it passes. Hence the cotidal lines for successive hours represent the successive positions of the summit of the tide wave, which in the open sea travels round the earth once in twenty-four hours, accompanied by another at twelve hours' distance from it, and both sending branches into the narrower seas. Thus a map of cotidal lines may be constructed, at once exhibiting to the eye the manner and the velocity of all these motions.

Although the observations on the periods of the tides at different places on the coast and different parts of the ocean, which have been at various times recorded, are exceedingly numerous, yet they are unfortunately for the most part too deficient in point of accuracy, or possess too little uniformity of connexion to afford very satisfactory results, or to admit of any extended comparison with theory. With a view to arrive at more correct conclusions, the author begins his inquiry by endeavouring to determine what may be expected to be the forms of the cotidal lines, as deduced from the laws which regulate the motions of water : and he proceeds afterwards to examine what are their real forms, as shown by the comparison of all the tide observations which we at present possess.

The paper is divided into five sections. In the first the author treats of cotidal lines as deduced theoretically from the known laws of the motion of fluids. On the supposition that the whole surface of the globe is covered with water, the cotidal lines would coincide with the meridians, and would revolve round the earth from east to west in something more than twenty-four hours, with a velocity of nearly 1000 miles an hour at the equator. The form and the regularity of these lines would be materially affected by the interposition of land in different parts of this ocean, whether in detached islands, or groups of islands, or large continents, occupying a considerable portion of the surface. In these cases the primary wave will be broken, deflected and variously modified, so as to give rise to secondary or derivative tides, sometimes separating into branches, and producing points of divergence ; sometimes uniting at various places, or points of convergence ; and at other times producing, by more complex combinations, various phenomena of interference, and other apparently anomalous results. Such is the general character of the tide-waves that actually proceed along the coasts of the Atlantic : and the modifications in their course and velocity are still more perceptible in bays, gulfs, and narrower channels and inlets of the sea, as well as in their progress along rivers. The author traces in detail the effects which these different circumstances may be expected to produce. He adverts to an important distinction which has frequently

been lost sight of, between the progressive motion of the tide-wave and the actual horizontal motion of the water, or tide-current ; motions which do not bear any constant relation to one another. Hence the change in the direction of the current does not invariably indicate the rise or fall of the water.

In the second section he examines the causes which have led to inaccuracy in making observations on the tides ; the first of which is dependent on the circumstance just mentioned, of the occasional want of correspondence between the times of *high* and of *slack* water ; the former referring to the moment of greatest elevation, the latter to that when the direction of the current changes. The other causes of error are derived from the change which takes place in the course of the day in the moon's angular distance from the sun ; from the half-monthly inequality in the establishment, arising from the relative position of the sun and moon during each lunation ; and from the necessity that exists of making a correction for what may be termed the *age* of the tide ; that is, the interval of time which has elapsed between the period of the origin of the wave and the time of its actual arrival at the place of observation.

The third section, which forms the chief bulk of the paper, is occupied by a statement and discussion of the tide observations now extant, and which the author has, with great industry, collected from a variety of sources, both of published accounts, and of manuscript documents preserved in the Admiralty. Commencing with the tide-waves, first of the eastern and then of the western coasts of the Atlantic, he follows them to the Northern sea, and to the different coasts of the British islands, and of the German Ocean. He passes next to the examination of those of the Southern Atlantic at Cape Horn and the adjacent coasts ; thence tracing them, as far as the present imperfect data will allow, along the western shores of the American continent, to the central parts of the Pacific, and in their progress across the Australian and Indian Oceans. He likewise examines the condition of the tides in rivers, as to the magnitude and velocity of the undulations, the occasional production of a high and abrupt wave, or *bore*, and as to the influence of the natural stream of the river upon the different periods of elevation or depression of the water.

The fourth section contains general remarks on the course of the tides, suggested by the preceding review of the phenomena they present ; on the velocity of the tide-wave ; on the form of the cotidal lines ; on the currents which attend the tides ; on the production of revolving currents ; on the magnitude of tides ; and on the constancy of the cotidal lines. He adverts also to some peculiarities resulting from interference, such as the differences of the two diurnal tides, and occasionally the occurrence of single day tides.

In the concluding section the author offers various suggestions respecting the most eligible mode of making observations on the tides, and of correctly reducing them when made.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1832-1833.

No. 13.

Report, drawn up by Samuel Hunter Christie, Esq. M.A., F.R.S., on Mr. Faraday's paper, entitled "Experimental Researches in Electricity:—Third Series."

Report.

§ VII. *Identity of Electricities from different Sources.*

§ VIII. *Relation, by measure, of Common and Voltaic Electricity."*

In order to prove the identity of electricities derived from different sources, the author in this communication, after viewing the phenomena exhibited by electricity, shows, that although some effects are most readily derived from a particular source, yet none are peculiar to such source. The principal points in which ordinary and voltaic electricity have been considered to differ, are the inefficiency of ordinary electricity to produce chemical decomposition, or to affect a magnetic needle like voltaic electricity. The experiments of Wollaston were made early in the application of electricity to chemical decomposition, before the general law of the transfer of the elements to the poles of the battery had been indicated; yet his 4th experiment, in which electricity from the machine was passed through a solution of sulphate of copper, and his 5th, where it was passed through a solution of corrosive sublimate, have the true characteristic of decomposition by voltaic electricity: and it is surprising that those who advocate a distinction between these electricities should have ventured to overlook these experiments, when they bring forward the experiment of the decomposition of water, as deficient in this characteristic of the transfer of the elements *. This circumstance, however, induced Mr. Faraday not merely to repeat Wollaston's 4th experiment, which he did with complete success, but to adopt different arrangements; and by these, with ordinary electricity, he obtained, in various instances, chemical decompositions having all the characters of decomposition by voltaic electricity. Whatever doubt, therefore, may have been thrown upon this part of the subject, he has entirely removed it.

The author has also removed the doubts which it appears had been entertained respecting the conclusion of M. Colladon, in consequence of the failure of his experiments in the hands of others. By a particular arrangement connected with the glass inclosing the galvanometer, and by retarding the passage of the electricity through its wires, by means similar to those by which gunpowder is most successfully

* Phil. Trans. 1832, p. 282, note.

exploded by an electric discharge*, which he also employed to effect chemical decomposition, Mr. Faraday succeeded in causing the needle to deviate, both by the discharge of a battery, and by electricity passing directly from the conductor of the machine. In justice to M. Colladon, we must remark, that the account which he gives of his experiments affords no reasonable ground for doubting the accuracy of his conclusions: the details are clear, and the numerous results unequivocal†. We may also notice, that, in the same memoir, M. Colladon gives an account of some very interesting experiments, made with a similar arrangement, on the magnetical effects of atmospherical electricity, by which its power of causing deviations of the needle is satisfactorily established.

Mr. Faraday, in the comparison which he makes between the effects produced by ordinary and by voltaic electricity, shows that the following, though differing in degree, are common to both, viz. attraction and repulsion, evolution of heat, magnetism, chemical decomposition, physiological phenomena, the spark. To these proofs of the identity of the electricities from these sources may be added, that batteries have been charged from the voltaic pile, and that the shock from a battery so charged could not be distinguished from that of the same battery charged to the same extent from the conductor of a machine‡. We consider that this alone is strong evidence in favour of the identity of the electricities, although we do not quite agree with Van Marum that it is conclusive.

The effects hitherto obtained from magneto-electricity, the author considers to be, evolution of heat, magnetism, physiological phenomena, the spark. He has not himself effected chemical decomposition by means of it; and he considers that the effects which have been obtained by others do not show true polar decomposition, but are similar to those obtained by Wollaston in the decomposition of water.

That magnetism and physiological phenomena are the only effects which have yet been obtained by means of thermo-electricity, the author attributes to its low degree of intensity.

Mr. Faraday considers that the identity of the electricity of the torpedo with common and voltaic electricity is satisfactorily established, although some effects, attraction and repulsion, due to a state of tension, evolution of heat, and the spark, have not yet been obtained: and in this we fully concur.

The general conclusion which the author draws from the collection of facts which he brings forward, is, that "electricity, whatever may be its source, is identical in its nature;" and he attributes the difference in the degree to which the phenomena, when originating in different sources, are observed, to the variable circumstances of quantity and intensity. This manner of accounting for the difference in the phenomena due to voltaic and to common electricity was adopted very early in the inquiry, common electricity being considered as ex-

* For this method of ignition we are indebted to Mr. W. Sturgeon. *Phil. Mag.* 1826.

† *Annales de Chimie*, 1826, tom. xxxiii. p. 62.

‡ *Annales de Chimie*, 1802, tom. xl. p. 289.

ceeding in intensity, but deficient in quantity. We however think, that it would be more in accordance with the phenomena to state, that as some effects require continuous action, they can only be obtained from ordinary electricity by rendering the quantity accumulated on a given surface (which quantity is a measure of the intensity,) available as a source of such action.

Although we agree with the author in the conclusions which he draws respecting the identity of electricities, yet there is one point, the mode of their conduction, in which they have been said to differ, on which we wish that he had made some remarks. The current of voltaic electricity runs through the mass of the conducting wire, and its intensity is diminished by increasing the length of that wire; and the same is the case with magneto-electric currents: but common electricity, in a state of tension, resides at or near the surface of a body, and has been considered to be so conducted*; and the shock has been found not to be diminished by the length of the wire through which it takes place. We would however ask, whether it is not a gratuitous assumption to state that electricity is conducted on the surface, because it exists there in a state of tension? That it exists near the surface when in a state of tension, is due to the repulsive force which its particles exert upon each other; and when they are relieved from tension, will not the same repulsive force spread them through the mass of the conducting body? With regard to the shock from a battery not being diminished by the length of the wire through which it takes place, does it not arise from the same quantity of electricity on a given surface being passed, when the equilibrium is restored, between the outside and inside of the battery, whatever may be the length of the conducting wire? We regret that the author's attention was not drawn to this part of the subject; for we feel assured, that had it been so, he would have met the objections which on this ground have been urged against the identity of the electricities. Possibly he was so fully convinced of the futility of these objections, that he considered it unnecessary to notice them.

The second section of this paper details experiments for determining the relation, by measure, of common and voltaic electricity.

The author first determines that the magnetical effect of a given quantity of common electricity from a battery is independent of the surface over which it is spread; and next, that this effect is proportional to the absolute quantity of electricity. The measures by the galvanometer are not professedly very accurate; but it is to be expected that experiments more accurate in this respect, and more varied with regard to the quantity of electricity, would confirm these conclusions. Determining, then, the quantity of voltaic electricity which in a given time will produce the same deflection of the needle as a given quantity of common electricity discharged from a battery, he shows that voltaic electricity of the same intensity will also, in that time, produce the same degree of chemical decomposition which that quantity of common electricity will when passed from the con-

* Phil. Trans. 1832, p. 280.

ductor. Although we are not quite satisfied with this manner of comparing the effects, because we consider that time enters very differently as an element in the several cases, yet we are sensible of the value of the experiments, and think that they strongly confirm the author's conclusions as to the identity of electricities from different sources.

This series of experimental researches in electricity, we consider, makes a very valuable addition to Mr. Faraday's former ones; and we have no hesitation in recommending its publication in the Transactions of the Royal Society.

S. H. CHRISTIE.

14th March 1833.

May 9, 1833.

WILLIAM GEORGE MATON, M.D., Vice-President, in the Chair.

A paper was read, entitled, "On the Anatomical and Optical Structure of the Crystalline Lenses of Animals, particularly that of the Cod." By Sir David Brewster, K.H., LL.D., F.R.S. V.P.R.S. Ed.

The author was led, by the observations he had made of some very singular phenomena in the crystalline lenses of fishes and quadrupeds when exposed to polarized light, to examine their minute anatomical structure, with the view of ascertaining if it had any relation to these optical appearances. He found that the crystalline lens of a cod has the form of a prolate spheroid, of which the axis coincides with that of vision. Its body is inclosed in an exceedingly thin and transparent capsule, within which it floats without having any apparent connexion with that capsule, and consists of a hard nucleus surrounded by softer matter. The nucleus is composed of regular transparent laminæ of equal thickness, with perfectly smooth surfaces, presenting the iridescent appearance peculiar to grooved surfaces, and exhibited by mother-of-pearl. These apparent grooves have the direction of meridian lines converging from the equator, where their breadth is greatest, to the two poles, and indicating the boundaries of the component fibres of the laminæ. The author was enabled to trace the course of these fibres to their termination very satisfactorily, when the fibres themselves could not be rendered visible by the best microscopes, by means of the reflected prismatic images of a luminous object, produced by interference. This method furnished also an accurate mode of determining the diameter of the fibres at any point of the spheroid. The uniform distribution of the light refracted through the lamina, as well as the distinctness of the reflected images, prove that these fibres are not cylindrical, but perfectly flat, and gradually tapering in breadth from the equator to the poles of the lens. The thickness of each fibre is at least five times less than its breadth, which, in the most external layer of the equator, is about the 5500th part of an inch.

The observation of another optical phenomenon apparent on looking at a bright light through a thin lamina of the lens of a cod, namely,

that of two faint and broad prismatic images, situated in a line perpendicular to that which joins the common coloured images, led the author to the further discovery of the mode in which the fibres are united laterally to each other, so as to resist separation, and form a continuous spherical surface. By viewing a well-prepared lamina with a microscope of high magnifying power, he observed that the fibres are united by a series of teeth, locking into one another, exactly like those of rack-work. The breadth and depth of each tooth are about the fifth part of the breadth of the fibre itself, and all the adjacent surfaces are in perfect optical contact. This denticulated structure exists in the lenses of every fish which the author examined. In that of the cod, the number of teeth in each fibre was found to be 12,500; and since the number of fibres in the whole lens is 5,000,000, the total number of teeth amount to 62,500,000,000.

The same structure obtains universally, as far as the author has examined it, in the lenses of birds; but he has never met with it in any of the Mammalia, not even in the Cetacea. It was found in two species of lizards, and in the *Ornithorhynchus*.

In the concluding part of the paper the author enters into some details as to the doubly-refracting structure of the crystalline lens of the cod and of other animals, in which several curious varieties are observable with regard to the relative positions of the strata giving positive or negative double refractions. In the prosecution of this subject he was led to the observation of a series of very curious phenomena, which he announces as the subject of a future communication to the Royal Society.

A paper was also read, entitled, "On the present Situation of the Magnetic Lines of Equal Variation, and their Changes on the Terrestrial Surface." By Peter Barlow, Esq., F.R.S.

The author has undertaken the task of collecting and arranging all the authentic information respecting magnetic variation which has been recorded in the accounts of several recent voyages and journeys of discovery. The inconvenience from the distortion and interruptions of the lines of equal variation laid down on maps or charts, induced him to trace them on a globe, where they can, of course, be exhibited in their natural situation, and in regular continuity: and he has been careful to mark only such as are deduced from actual observation. The examination of the lines thus laid down shows them to be dependent on definite and general laws, and not on local influences; their inflexions and curvatures presenting systems of great regularity, and being exempt from those abrupt and angular configurations which such local disturbances might be expected to produce: neither do they appear to be consistent with the hypothesis of the action of a certain definite plurality of magnetic poles.

The author next offers some observations on the progressive changes which these lines undergo in their places and configurations, and shows their agreement with the hypothesis of a revolution of the magnetic poles for each place round the poles of the earth; each respec-

tive place having its own particular pole, the revolving motion of which is regulated by some general but hitherto unknown law.

May 16, 1833.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

A paper was read, entitled, "Note on a Paper by Dr. John Davy, entitled, 'Notice on the Remains of the recent Volcano in the Mediterranean.'" By Charles Daubeny, M.D., F.R.S., Professor of Chemistry in the University of Oxford.

From the circumstance that azotic gas is frequently evolved from thermal springs, the author infers that this phenomenon is in some way connected with volcanic action; and this he considers to be the case in the instance observed by Dr. Davy, although referred by him to the decomposition of atmospheric air during putrefactive processes going on at the bottom of the sea. Dr. Daubeny offers objections to the theory of that gas rising to the surface in consequence of the high temperature to which it has been subjected. He conceives that the air which Dr. Davy examined cannot have been derived from seawater, but must have originated from the atmosphere itself, with which the volcano communicated. The author is disposed to attach great importance to the accurate examination of the gases given out by warm springs, and recommends the prosecution of the inquiry.

A paper was also read, entitled, "Experimental Researches on Atomic Weights." By Edward Turner, M.D., F.R.S. Lond. and Edinb., Professor of Chemistry in the University of London.

This paper is a continuation of the Essay, by the same author, on the Composition of the Chloride of Barium, which was published in the Philosophical Transactions for 1829. Having shown that the atomic weights current among British chemists, though in some instances correct, or tolerably approximative, have, as a whole, been adopted on insufficient evidence, he proceeds, in this paper, to give an account of the experiments he has made to ascertain the equivalent numbers for lead, chlorine, silver, barium, and nitrogen. Finding, with reference to lead, that the method adopted by Berzelius did not afford uniform results, he endeavoured to ascertain the quantity of subsulphate of lead which given weights of metallic lead and the protoxide of that metal respectively produce. He details the mode he employed for the conversion of metallic lead into the subsulphate by a mixture of nitric and sulphuric acids, diluted with an equal bulk of water, and the precautions he adopted to avoid loss. The mean of three experiments gave 146.375 grains of sulphate of lead for 100 grains of metallic lead. By the mean of four experiments, Berzelius had obtained, instead of the former number, 146.419. Dr. Turner adopts the mean of the whole, namely, 146.41. By prosecuting this inquiry,

he finds the sulphate to consist of 73·575 of protoxide of lead, and 26·425 of sulphuric acid; and that the former contains 5·274 of oxygen. According to these results, the equivalent number for lead is 103·6.

By experiments with the chloride of lead, which gave very uniform results, Dr. Turner obtained an equivalent number for chlorine, closely agreeing with that calculated from the analysis of chlorate of potash in the experiments of Berzelius, namely, 35·45, but totally inconsistent with the atomic weight assigned to it by British chemists. The accuracy of this result was further confirmed by a careful comparative analysis of the binoxide and bichloride of mercury.

The author next endeavoured to determine the equivalent number for silver, by the analysis of its oxide and sulphuret, but could not arrive at any precision in his results. The equivalent number for barium may be calculated from his analysis of the chloride already published in the paper before alluded to. His investigation of the equivalent of nitrogen was attempted by means of the analysis of the nitrates of silver, of lead, and of baryta; the mean result of which gives 14·15, agreeing very nearly with that assigned by Berzelius. His investigation of the atomic weight of sulphur is not yet completed; but he details several previous steps in this inquiry, which he intends to prosecute on a future occasion. He estimates the equivalent of mercury at 202; a number which he considers as a close approximation.

He concludes by various remarks on the inconsistency with experiment, which is apparent in many of the numbers adopted as chemical equivalents by British chemists; and on the inaccuracy of those numbers which have been employed as elements in calculating the equivalents of nearly all the other elementary substances. The author thinks that Dr. Prout's hypothesis, as advocated by Dr. Thomson, that all atomic weights are simple multiples of that of hydrogen, can no longer be maintained, and that it is at variance with the most exact analytical researches.

May 23, 1833.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

A paper was read, entitled, "Observations of the Comet of Encke, made in June 1832." By Thomas Henderson, Esq., His Majesty's Astronomer at the Cape of Good Hope. Communicated, by Command of the Lords Commissioners of the Admiralty, by Captain Beaufort, R.N., F.R.S., Hydrographer to the Admiralty.

Most of the observations recorded in this paper were made by a circular micrometer constructed by Simms, and applied to an achromatic telescope of Dollond's, 45 inches in focal length, and 3·5 inches aperture, furnished with a portable equatorial stand, capable of being adjusted to any latitude. The magnifying power was about 30, and the radius of the ring was an arc of 1015 seconds. In other observa-

tions, a transit instrument by Dollond was used, which was 10 feet in focal length, and 4·75 inches aperture. For observing the comet, an eye-glass magnifying 86 times was employed.

A paper was then read, entitled, "On the supposed Powers of Suction of the Common Leech." By Thomas Andrew Knight, Esq., F.R.S., President of the Horticultural Society.

From observing the feebleness of the muscular force exhibited by the leech in its progressive movements through the water, the author was led to doubt its possessing the powers of suction that are so universally ascribed to it. A fact which came under his notice above sixty years ago, of considerable loss of blood from the leg following the bite of a vigorous leech, suggested to him the idea that the animal might become filled with blood simply by the injection of its body, in consequence of the impetus with which the blood is made to flow into it from the part bitten;—an impetus which he imagines may be occasioned by the introduction of a peculiar kind of venom. He considers the irritation which often accompanies the bite of a leech as corroborating this hypothesis: he admits, however, that the inflammation excited by the sting of a bee or a wasp is attended with effects of a totally opposite kind; for, in that case, the blood, instead of having a tendency to flow, stagnates around the point where the poison has been instilled.

A paper was also read, entitled, "Experimental Researches in Electricity.—Fourth Series." By Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain.

The author, while prosecuting his researches on electro-chemical decomposition, observed some phenomena which appeared to be referable to a general law of electric conduction not hitherto recognised. He found that an electric current from a voltaic battery, which is readily conducted by water, did not pass through ice: even the thinnest film of ice, interposed in the circuit, was sufficient to intercept all electric influence of such low intensities as that produced by the voltaic apparatus, although it allows of the transmission of electricity of such high intensity as that excited by the common electrical machine. The author ascertained that a great number of other substances, which are solid at ordinary temperatures, do not conduct the electric current from the voltaic battery until they are liquefied. Among these are potassa, protoxide of lead, glass of antimony, and oxide of bismuth; various chlorides, iodides, and sulphurets; and also many of the ordinary neutral salts with alkaline bases. In almost every instance the bodies subjected to this law are decomposable by electricity; and their decomposition can be effected only when they are in a fluid state, and while they are conductors of electricity. The author inquires how far these two properties are connected together, or dependent the one upon the other; but finds that several exceptions occur to any general proposition that he attempted to establish on this subject.

The general conclusions to which he is led from the experiments detailed in this paper are the following :—First, that all bodies conduct electricity in the same manner, but in very different degrees ;—Secondly, that in some the conducting power is powerfully increased by heat, in others diminished, and this without any difference that has yet been discovered, either in the general nature of the substance, or of the influence of electricity upon it ;—Thirdly, that there is a numerous class of bodies which, when solid, insulate electricity, and, when fluid, conduct it freely, and are decomposed by it ; yet that there are many fluid bodies which do not sensibly conduct electricity of low intensity ; and some that conduct it, and are not decomposed ;—and, Lastly, that fluidity is not essential to decomposition. Sulphuret of silver is the only body yet known to be capable of insulating a voltaic current when solid, and of conducting it, without decomposition, when fluid. No distinction can as yet be drawn between the conducting powers of bodies supposed to be elementary and those known to be compounds.

The Society then adjourned over Whitsun-week to the 6th of June.

June 6, 1833.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

Captain John Lihou, R.N., was elected a Fellow of the Society.

Professor Desfontaines, of Paris ; Professor C. G. J. Jacobi, of Königsberg ; Baron von Lindenau, of Gotha ; Professor Meckel, of Halle ; and M. G. de Pontécoulant, of Paris, were elected Foreign Members of the Society.

A paper was read, entitled, “ An Account of a Second Series of Experiments on the Resistance of Fluids to Bodies passing through them.” By James Walker, Esq., F.R.S., Civil Engineer.

The author, in a paper read to the Society in the year 1827, and printed in the *Philosophical Transactions*, gave an account of some experiments showing that the resistance of fluids increases in a ratio considerably higher than the square of the velocity, and that the absolute resistance is smaller than had been deduced from the experiments of the French Academy. In the present communication he states the results of his further inquiries on this subject. His experiments were made at the East India Docks, on a boat twenty-three feet long and six wide, with the stem and stern nearly vertical ; one end being terminated by an angle of 42° , and the other of 72° ; and the resistance to the boat's motion being measured by a dynamometer. The results are given in tables : and it appears from them, that in light vessels sharpness is more important in the bow than in the stern ; but that the reverse is the case in vessels carrying heavy cargoes. From another series of experiments the author infers that the resistance to a flat surface does not exceed 1.25lb. for each square

foot, at a speed of one mile per hour ; increasing, for greater velocities, in a ratio considerably higher than the square of the velocity.

The author concludes with some observations on the results lately obtained in Scotland, where great velocities were given to boats moving on canals, without a proportional increase of resistance.

The reading of a paper, entitled, "Researches on the Arseniates, Phosphates, and Modifications of Phosphoric Acid," by Thomas Graham, Esq., M.A., F.R.S.E., Lecturer on Chemistry in the Andersonian Institution of Glasgow; communicated by Edward Turner, M.D., F.R.S.—was commenced.

June 13, 1833.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

Mr. Graham's paper was resumed and concluded.

The tendency of the arsenic and phosphoric acids to form subsesquisalts with the oxides of silver and lead is well known ; corresponding salts with alkaline bases also exist. The author describes the method of forming the subarseniate and subphosphate of soda, and their properties ; and shows that they are subsesquisalts, containing one proportion and a half of base to one of acid. They are the only known soluble salts of that constitution ; and it is remarkable, that the acid of the subphosphate of soda is not convertible into pyrophosphoric acid by the action of heat, like the acid of the common phosphate of soda. This may be explained on the hypothesis, that phosphoric acid, in contradistinction to pyrophosphoric acid, contains an atom of water, which stands in a basic relation to the acid, and which may be replaced by an atom of any of the usual bases. Hence also arises the disposition of phosphoric acid to form subsesquisalts ; for the common phosphate, used as a precipitant, exchanges its basic water for a fixed base ; and for this reason, likewise, phosphate of soda, or any neutral phosphate, cannot be made anhydrous without becoming a pyrophosphate ; but the subphosphates having an excess of base, may be anhydrous, as Stromeyer observed ; and indeed they are not convertible into pyrosalts. The acid formed by the combustion of phosphorus in air or oxygen, constitutes a third modification of phosphoric acid, distinguished by peculiar properties, and which, from the difference of its saturating power, in relation to that of the phosphoric and pyrophosphoric acid, the author considers as a *polymeric* phosphoric acid ;—a term lately applied by Berzelius to bodies of the same relative composition, but differing in their combining proportions.

The author devoted much time and attention to determine the quantity of water of combination in the foregoing subsalts ; but the result he obtained, namely 50.22 per cent., is not easily reconciled with our best data for atomic weights. It is, however, pretty nearly compatible with 23 or 24 atoms of water, according to Berzelius's weight of the atom of arsenic ; and if the latter estimate be correct, it is curious

that the subarseniate differs from the neutral arseniate, merely by the substitution of an atom of soda for an atom of water; for the latter salt contains 25 atoms of water.

The author's experiments on the composition of the subarseniate of soda,—the results being reduced to the hypothesis, that it contains 23 atoms of water,—represent it as formed, (per cent.) of arsenic acid, 27.69; soda, 22.55; water, 49.75. The subphosphate of soda was found to consist (per cent.) of subsesquiphosphate, 43.97; water, 56.03; the soda in the salt amounting to 24.87.

The author attempted to determine the quantity of phosphoric acid in this salt, by direct precipitation by nitrate of silver, but could not obtain rigorously accurate results; for the subphosphate of silver carried down with it a portion of the nitrate, which washing could not entirely separate. He likewise failed in his endeavours to obtain pure subphosphate and subarseniate of potash.

The subarseniate of barytes appeared, by a single experiment, to be composed, (per cent.) of arsenic acid, 32.06; barytes, 67.94: from which the salt would seem to contain an excess of base; for by theory, the subsesquiarseniate of barytes should be composed of, acid, 33.4; base, 66.6.

When solution of muriate of lime is poured into an excess of solution of phosphate of soda, or when phosphate of lime, dissolved in muriatic acid, is precipitated by ammonia, a gelatinous mass is formed, which has been called the subphosphate of lime of bones; the composition of which is singular, consisting, on the simplest view that can be taken of it, of 3 atoms of phosphoric acid, and 4 of lime. It was noticed by Berzelius.

The author thinks the anomalous composition of this salt may in some measure be explained by considering it as consisting of 1 atom of the neutral, and 2 atoms of the subsesquiphosphate. According to Berzelius, calcined ox-bones are composed of such a phosphate of lime, with a little carbonate of lime; but a doubt arises of the accuracy of this view, from the fact, that the presence of carbonic acid in the calcined phosphate of bones is no proof of the existence of that acid in the same, previous to calcination.

The earth of bones, after calcination at a high temperature, contains phosphoric, and not pyrophosphoric, acid; the excess of base preventing the transition.

The author's analysis of subarseniate of lead, formed by the gradual addition of solution of acetate of lead to solution of subarseniate of soda, afforded a striking confirmation of the atomic weight of arsenic, deduced by Berzelius from his analysis of arsenious acid by sulphur.

A paper was read, entitled, "Some Observations on the Structure of Shells, and on the Economy of Molluscous Animals." By John Edward Gray, Esq. F.R.S.

The author distinguishes two kinds of structure in shells; the one in which the calcareous matter is crystallized, composing what Mr. Hatchett has called the *porcellaneous structure*; and the other, in which it is deposited in grains intermixed with a large proportion of

animal matter, constituting the *nacreous* or *granular structure*. The former class of shells, which includes most of the turbinated univalves, may be divided into those in which the crystals are rhombic, and those in which they are prismatic. The first are composed of three distinct layers, the laminæ of which are disposed differently in the intermediate layer from what they are in the outer and inner layers. The direction of the fibres of each being nearly at right angles to that of the contiguous layer, the strength of the shell is rendered considerably greater than if the arrangement of the fibres had been uniform in each plate. The comparative thickness of the three plates varies in different shells; but the central plate is generally the thickest. The outer plate is the thinnest; and, in some shells, is easily detached, in consequence of the deposition underneath it of a white film of less coherent matter. It often happens, that when the animal arrives at its full size, it deposits layers of shell either on the lips or the columella: and in some, as the *Cyprææ*, an additional coat, which is harder, more compact, and differently coloured from the rest of the shell, is formed by an extension of the mantle, and laid on the outside of the shell; the part, where the two reflected portions of the mantle meet on the back being marked by what is termed the *dorsal line*.

Besides these component parts of turbinated shells, there is often deposited on the sides and interior part of their cavities, especially of the upper whorls, a transparent calcareous concretion. In shells of which the spires are elongated and acute, as in the *Turritellæ*, this deposition entirely fills up the cavity of the upper whorls; thus rendering solid the tips, which, from their small size and original thinness, would otherwise have been very liable to be broken. In other cases the animal, instead of filling up this upper cavity, suddenly withdraws its body from the upper whorls, and then forms a concave septum, by which the vital communication between the body and the apex of the shell being cut off, this part decays as a dead shell, and gradually falls to pieces.

Shells having a prismatic crystalline structure are formed of short fibres, everywhere perpendicular to the surface. The prisms are mostly hexagonal. Shells of a granular structure present a more uniform texture; the plates of animal matter they contain being very thin, and closely compacted together. They have generally a pearly or iridescent lustre, arising from this peculiar conformation. The particles of disintegrated *Placunæ* are employed by the Chinese as silver in their water-colour drawings. In many shells belonging to this class, as in the Oyster, the animal matter, being more abundant, produces a distinctly laminated texture.

It has been generally believed, and sometimes strenuously maintained, that molluscous animals have not the power of absorbing the matter of their shells when it has once been deposited. The author brings forward a large mass of evidence in proof of their frequently exercising this power. In the Cone and the Olive, all the septa between the whorls inclosed in the body are very thin and transparent, and, when compared with the corresponding portions of the outside,

adjacent to the apex, are found to have lost the outer and the middle layers, the innermost alone remaining. In the *Auriculæ*, this inner layer also is removed, leaving a simple cavity in the upper half of the shell. The absorption of the substance of these internal portions of shell gives more space for the body, at the same time that it renders the shell much lighter, without any diminution of its strength; the body being sufficiently protected by the outer whorl. In the *Murices*, and other shells having ridges or spines on the front of the whorls, which, in the progress of the growth of the shell, the succeeding whorls would necessarily overlap, these appendages are generally absorbed, to make way for the succeeding whorls; their absorption being effected by the edge of the mantle as it comes in contact with them. Thus do many species of Mollusca absorb, at regular epochs of their growth, certain parts of their shells, which had, at a preceding period, been deposited about the lip in the form of ribs or teeth. Mollusca have also the power of forming excavations in the shells of other animals of this class, and sometimes of other individuals of the same species: many instances of these facts are adduced by the author; among which one of the most curious is the history of the *Spiraglyphus*, which, in the progress of its enlargement, absorbs a tubular portion of shell which it had formed at an early period of its growth. They also excavate portions of solid rock in providing for their habitation. Molluscan animals, however, do not appear to be capable of removing extraneous obstacles which oppose their progress in the formation of their shell; in proof of which, various examples are adduced of foreign bodies being inclosed in the layers of shells. The author produces evidence of the secretion of the materials of the shell by other parts than the mantle, and in particular by the upper part of the foot. The operculum is in this way formed, in a manner exactly similar to shell, by the back of the foot: and its various modifications of form, the author remarks, afford important characters for the systematic classification of this department of Natural History.

June 20, 1833.

WILLIAM GEORGE MATON, M.D., Vice-President, in the Chair.

His Grace the Duke of Buccleuch, and the Right Hon. Sir Thomas Denman, were elected Fellows of the Society.

Professor Stromeyer, Foreign Memb. R.S., presented two specimens, one of the coarse-grained, the other of the fine-grained variety, of the remarkable mass of iron lately discovered near Magdeburg, and an account of which had been laid before the Royal Society of Göttingen on the 14th of last month. This iron was found, in several detached lumps, about four feet below the mould, by Mr. Kote, who considered himself the more authorized to pronounce it meteoric, as, in the chronicles of Magdeburg, the descent of a fiery meteor is recorded as having happened in the year 998. Professor Stromeyer has subjected this iron to a minute analysis, the results of which are very interesting, inasmuch as, besides the alloy of nickel and cobalt, usu-

ally present in meteoric iron, he unexpectedly found a considerable portion of molybdenum,—a rare metal on our planet, occurring only in two combinations, viz. with sulphur, as glance molybdenum, and, as molybdic acid combined with oxide of lead, in the yellow lead ore of Carinthia and a few other places.

The following are the external characters of the six masses dug up, the largest of which was about fifty-seven pounds in weight; the others were considerably smaller. Their shape is more or less oval and flat, with surfaces rather oxidated, and here and there covered with an earthy crust. The larger lumps did not exhibit any trace of scoræ; but in some of the smaller pieces, part of the metallic mass had passed into a porous slag-like body; of which latter a few detached pieces were likewise found. This iron possesses no degree of ductility; it is not attacked by the saw, and but slightly and with difficulty by the file. Its tenacity, however, is considerable; the masses required great strength to be broken; but small fragments did not oppose greater difficulty to be reduced to a coarse powder than white cast-iron; and glass was but slightly scratched by them. On the fresh fracture, this iron exhibits upon the whole a scaly-granular structure; its internal lustre is moderately vivid, and its colour tin-white, with a strong cast of grey. Two varieties of texture were, however, observable; in some fragments it was more distinctly scaly, of a coarser grain and a deeper grey colour, united to a greater degree of tenacity. The specific gravity of the coarse-grained variety (barom. 0^m.758, therm. 21°·5 c.) = 7·2182; that of the fine-grained = 7·3894.

The mass contained much of a sulphuret not unlike in appearance to variegated copper ore, from which the subsequent analysis proved it not to differ in composition, except that a trace of sulphuret of silver was found in it. Also minute portions of capillary native copper were found in the interior of some pieces, together with here and there some translucid, pale yellow, olivine-like grains, but in too small quantities to admit of chemical examination.

Professor Stromeyer proceeds to give a detailed account of the chemical analysis to which this iron was subjected by him; according to which 100 parts are composed of—

	a. Coarse-grained variety.	b. Fine-grained variety.
Iron	76·77	74·60
Molybdenum	9·97	10·10
Copper	3·40	4·32
Cobalt	3·25	3·07
Nickel	1·15	1·28
Manganese	0·02	0·01
Arsenic	1·40	2·47
Silicium	0·35	0·39
Phosphorus	1·25	2·27
Sulphur	2·06	0·92
Carbon	0·38	0·48
	<hr/> 100·00	<hr/> 100·00

From this it appears, that though the Magdeburg iron contains all the ingredients characteristic of meteoric iron, it is essentially distinct from all others hitherto examined, by the presence of molybdenum and arsenic ; by the smaller and rather anomalous proportion of nickel and cobalt which enters into its composition ; by the admixture of some capillary copper and of variegated copper ore, instead of the magnetic pyrites found in some meteoric iron ; and, lastly, by the presence, though only a trace, of sulphuret of silver.

Professor Stromeyer then enters into an examination of the circumstances which appear opposed to the opinion which assigns a meteoric origin to this iron, and of the objections against its being the product of artificial fusion ; among which, one of the greatest is its considerable alloy of molybdenum,—a metal which has hitherto not been observed either in ores of iron and copper, or in any slags or other products of smelting furnaces. But Dr. Stromeyer has since obtained, from the Hartz Mountains, a similar and equally problematical mass of iron, the analysis of which has furnished nearly the same results as that of the Magdeburg iron, except that it contained no variegated copper ore. Future observations will probably throw more light upon the nature of these enigmatical metallic bodies ; at all events, the discovery of molybdenum in them is so far of great interest, as, in case they should ultimately prove to be artificial products, it is fair to conjecture that that scarce metal must enter into combinations still unknown to the chemical mineralogist, or occur in some ores in a masked state and such small proportions as to become (like titanium) apparent only in the products of the long-continued operations of the smelting furnace.

The following papers were read :—

1. "Observations on the Physiology of the Nerves of Sensation, illustrated by a case of Paralysis of the Fifth Pair." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The influence of the fifth pair of nerves on the functions of sight, smell, and taste, is a subject which has lately occupied the attention of physiologists. Many experiments have been made on living animals with a view to its elucidation ; but these experiments have never led to any satisfactory conclusion. Considerable light has been thrown upon this obscure question by the phenomena attending a case of paralysis of the fifth pair of nerves, which occurred in the author's practice, and of which he gives the history in detail, after quoting the account given by Magendie of his experiments and speculations respecting the functions of these nerves.

The lady who was the subject of these observations had been affected with total insensibility of the left side of the face and head, together with strabismus, accompanied with double vision ; but the powers of voluntary motion of all these parts remained entire. The globe of the left eye was quite insensible to touch, though it retained the power of vision unimpaired, excepting that for some time previous to death it had lost the faculty of distinguishing colours. The left nostril received no impressions from the most irritating stimulants,

such as snuff or ammonia ; yet the sense of smelling continued unimpaired. The left side of the tongue was quite insensible to impressions both of touch and of taste. On examining the brain after death, a scirrhus tumour was found lying on the inner surface of the sphenoid bone, extending laterally to the foramen auditorium internum, and resting posteriorly on the pons Varolii, which was slightly ulcerated. The tumour had completely obliterated the foramina for the exit of the three branches of the fifth pair of nerves. This case proves, therefore, that, contrary to the opinion of Magendie, the senses of smell and vision can be exercised independently of the fifth pair of nerves ; and that the sense of taste is altogether derived from that nerve ; and corroborates the views of Sir Charles Bell on this part of physiology.

2. "On the Respiratory Organs of the Common Leech (*Hirudo officinalis*, Linn.), and their Connexions with the Circulatory System." By George Newport, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The stomach of the leech has been hitherto described as a large elongated sac, simply divided into ten compartments by perforated membranous partitions : but the author, by a more accurate examination, finds that each portion of that organ is expanded into two lateral cæca, which increase both in size and in length as they are traced along the canal towards the pylorus. The cæca belonging to the tenth cavity are the longest, extending as far as the anus, and have themselves four constrictions : the cavity itself terminates in a funnel-shaped pylorus. When the posterior end of the animal is cut off, the cæcal portions of the stomach are laid open, and the blood which it receives flows out freely, as fast as it is swallowed ; and hence the leech, under these circumstances, continues to suck for an indefinite time.

The respiratory organs consist of two series of pulmonary sacs, arranged along the under side of the body, on each side of the nervous cords and ganglia. They each open upon the surface of the body by a very minute but distinctly valvular orifice. The membrane which lines them appears to be continuous with the cuticle, and is exceedingly delicate and highly vascular, receiving the blood, for the purpose of its being aerated, from the veins of the system. The blood is returned from these sacs into the lateral serpentine vessels by vessels of a peculiar construction, passing transversely, and forming loops, which are situated between the cæca of the stomach, and which are studded by an immense number of small rounded bodies closely congregated together, and bearing a great resemblance to the structure of the *venæ cavæ* of the cephalopodous Mollusca. The purpose answered by this structure is involved in much obscurity : the author offers a conjecture that they may be analogous in their office to the mesenteric glands of the higher animals.

With a view to determine some circumstances relating to the mode of the respiration of the leech, the author made some experiments, by confining the animal in water deprived of air by boiling. After some

time the leech was observed to give out bubbles of air ; and the water of the vessel, when tested by lime-water, indicated the presence of carbonic acid.—The paper is accompanied by drawings of the structures described.

3. "On the Comparative Osteological Forms in the Adult European Male and Female of the Human Species." By Walter Adam, M.D., Fellow of the College of Physicians of Edinburgh.

With a view to the future investigation of the osteological development of the human race, the author gives, in the present paper, the results of a great number of measurements, which he has very carefully made, of the dimensions of the different bones composing the adult human skeleton. The male bones examined were those in the collection of Dr. Monro ; the female bones were furnished by Dr. Hamilton. The author was anxious to fix on some one dimension in the skeleton which might be taken as the standard of all the measurements : and finding that no bone of the trunk or limbs possessed the requisite characters for that purpose, he sought for it in the cranium ; and the result of an extensive series of observations led him to adopt as the standard of measure the distance between the prolongations of the zygomatic ridges, immediately over the meatus auditorius externus, as being that dimension which was less liable to variation than any other of the human cranium. This line he denominates the *auricular transverse* ; and, adopting a scale of which the unit is the 14th part of this line, being generally about the third of an inch, he states at length, in multiples of this unit, the dimensions, in different directions, of almost every bone in the skeleton ; noting more especially the differences that occur in those of the two sexes. Of these measurements, which are given in much detail, and in many instances arranged in a tabular form, it is impossible to give any abridgement. The conclusion he deduces from his inquiry is, that every bone in the body exhibits certain modifications, according to the sex of the individual.

4. "Some Experiments and Observations on the Combinations of Carbonic Acid and Ammonia." By John Davy, M.D., F.R.S.

The author was led to the investigations of which he gives an account in the present paper, by finding in the note-books of his brother, the late Sir H. Davy, some memoranda of experiments which he had made on the salts of ammonia, and more especially on the carbonates. The first part of the paper relates to the direct combination of carbonic acid and ammonia, by which a salt is formed possessing singularly alkaline properties. The second is on the sesquicarbonate of ammonia ; a term which Mr. Richard Phillips has applied to that salt of ammonia which is commonly called the subcarbonate, and which is obtained by the mutual decomposition of carbonate of lime and sal-ammoniac, by means of heat. This the author concludes, from his experiments, to be composed of one proportion ammonia, one and a half of carbonic acid, and one of water. He then enters into a comparative review of the analyses of this salt by other chemists, and

gives an account of the results of his experiments to determine its solubility at different temperatures. He next proceeds to consider the bicarbonate of ammonia, which he finds to consist of one proportion of ammonia, two of carbonic acid, and two of water. He concludes by an inquiry into the effects of heat on the solid sesquicarbonate and the carbonate of ammonia, in which he reviews the experiments and inferences which Sir H. Davy has recorded in his manuscript notes.

5. "On the Influence of Colour on Heat and Odours." By James Stark, M.D., of Edinburgh. Communicated by Sir David Brewster, K.H., LL.D., F.R.S. V.P.R.S. Ed.

The author observes, that the only experiments on record relating to the modifying effect of different colours on the absorption of heat from solar light, are those of Franklin and of Sir H. Davy. In order to investigate this subject, the author employed pieces of wool, silk, and cotton, which were wrapped round the bulb of a thermometer placed in a glass tube: the tube was then plunged into boiling water, and the time which elapsed during the rise of the thermometer from one given point to another was accurately noted. Other experiments were also made with an air-thermometer, of which the bulb was coated with various coloured materials, and heat thrown on the ball by means of polished tin reflectors from an Argand burner. The results accord very nearly with those of Franklin and of Davy; the absorbing power with regard to different colours being nearly uniformly in the order of *black, brown, green, red, yellow, and white*. The author next investigates the differences which occur in the radiation of heat by differently coloured substances; a subject on which he is not aware that any experiments have ever been made previously to his own. The mode of ascertaining the amount of radiation was generally the converse of that by which the absorption of heat had been determined; namely, by exposing the coloured substances, in contact with a thermometer, to cooling instead of heating processes. The general result of all his experiments was, that the loss of caloric by radiation follows exactly the same order, with regard to the colour of the radiating surface, as its absorption.

In the second part of his paper the author gives an account of a course of experiments which he made with a view to discover the influence of colour on the absorption of odorous effluvia, and more especially in the case of the absorption of the fumes of camphor and assa-fœtida by woollen cloth of different colours. Black cloth was always found to be possessed of the greatest absorbing powers, and white of the least; red cloth being intermediate between them. Cottons and silks gave, on trial, precisely the same results, which were further confirmed by the different weights acquired by these substances from the deposition of camphor upon them.

6. "Researches on the Arseniates, Phosphates, and Modifications of Phosphoric Acid." By Thomas Graham, Esq., M.A., F.R.S.E., Lecturer on Chemistry in the Andersonian Institution at Glasgow. Communicated by Dr. Turner, F.R.S.

This paper, which forms the sequel to the one on the same subject which was read at the preceding meeting, continues the inquiry into the combinations of phosphoric acid with different bases, and more particularly with soda. The crystallized salt of phosphate of soda was found to contain 37.1 of the phosphate, and 62.9 of water; so that the author infers its composition to be three atoms base, namely, two of soda and one of water. The pyrophosphate of soda, on the other hand, contains only two atoms soda as base, and gives accordingly bibasic precipitates. The biphosphate of soda was found to admit of so great a number of changes in its composition and properties, as to render it an object of great interest. Of the four atoms of water which the crystals contain, they lose two atoms at the temperature of 212° , and not a particle more till the heat is raised to about 375° . There is every reason to believe that the two atoms of water retained are essential to the constitution of the biphosphate of soda; and that it contains three atoms of base, namely, one atom soda to two atoms water, united to a double atom of phosphoric acid. Other varieties of this salt are also met with; the first of which may be called a bi-pyrophosphate, containing only one atom of basic water; the second being anhydrous, though soluble in water, and neutral in its reaction on litmus, but of which the exact composition is not well determined; the third being an insoluble variety; and a fourth being a metaphosphate of soda,—the author designating, by the term Metaphosphoric acid, a peculiar hypothetical state of composition of the elements of phosphoric acid in conjunction with water. This new acid enters into combination with barytes and with lime, forming with these bases other metaphosphates. The author concludes by a general review of the several modifications of phosphoric acid which have resulted from these inquiries.

7. "On the Developement of the Disturbing Function upon which depend the Inequalities of the Motions of the Planets, caused by their Mutual Attraction." By James Ivory, Esq., K.H., M.A., F.R.S.

The progress of physical astronomy has been retarded by the excessive labour requisite for the arithmetical computation of the inequalities in the motions of the planets, arising from the perturbations produced by their mutual attractions. If an inequality depended solely on the quantity of the coefficient of its argument in the expanded algebraic function, the difficulty of computation would not be great, since, from the smallness of the elements on which it depends, namely, the eccentricities and the inclinations of the orbits to the ecliptic, the resulting series decreases, in every case, with great rapidity: but as its magnitude depends also upon the length of its period, the coefficient of its argument will, when this period embraces many years, acquire, in the process of integration, a high multiplier, and comes thus to have a sensible effect on the place of the planet.

Such is the origin of some of the most remarkable of the planetary inequalities, and, in particular, of the great equations in the mean motions of Jupiter and Saturn. It is necessary, therefore, that the astronomer be furnished with the means of computing any term in the expansion of the disturbing function below the sixth order; since it has been found that there are inequalities depending upon terms of the fifth order, which have a sensible effect on the motions of some of the planets. The object of the author in the present paper is to give the function such a form that the astronomer may have it in his power to select any inequality he may wish to examine, and to compute the coefficient of its argument by an arithmetical process of moderate length. The investigation comprehends every argument not passing the fifth order; but as the formulæ are regular, the method may be extended indefinitely to any order.

8. "On the Reflex Function of the Medulla Oblongata and Spinalis, or the principle of Tone in the Muscular System." By Marshall Hall, M.D., F.R.S. L. & E.

The author, after commenting on the opinions of Le Gallois and Cruveilhier relating to the functions of the spinal marrow, adverts to a property or function of the medulla oblongata and spinalis, which he considers as having escaped the notice of these and all other physiologists; namely, that by which an impression made upon the extremities of certain nerves is conveyed to these two portions of the nervous system, and reflected along other nerves to parts different from those which received the impression. He distinguishes muscular actions into three kinds: first, those directly consequent on volition; secondly, those which are involuntary, and dependent on simple irritability; and thirdly, those resulting from the reflex action above described, and which include those of the sphincter muscles, the tonic condition of the muscles in general, the acts of deglutition, of respiration, and many motions, which, under other circumstances, are under the guidance of the will. Volition ceases when the head or brain is removed; yet, as he shows by various experiments, movements may be then excited in the muscles of the limbs and trunk, by irritations applied to the extremities of the nerves which remain in communication with the spinal marrow: but these actions cease as soon as the spinal marrow is destroyed. Hence the author concludes that they are the effect of the reflex action of the spinal marrow, which exists independently of the brain; and, indeed, exists in each part of the organ independently of every other part. He considers that this reflex function is capable of exaltation by certain agents, such as opium and strychnine, which in frogs produce a tetanic and highly excitable state of muscular irritability. Hence he is led to view the reflex function as the principle of tone in the muscular system. He considers that certain poisons, such as the hydrocyanic acid, act by destroying this particular function. The effects of dentition, of alvine irritation, and of hydrophobia, of sneezing, coughing, vomiting, tenesmus, &c. &c., are adduced as exemplifications of the operation of the same principle when in a morbid state of exaltation.

9. "Experimental Researches in Electricity.—Fifth Series." By Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain.

The object of the author in this paper is to investigate the nature of electro-chemical decomposition. From the consideration of the circumstances of difference that mark the electricities obtained from the common electrical machine, and from the voltaic battery, and of which he had already established the theory in preceding papers, he was led to expect that the employment of the former in effecting chemical decomposition would exhibit some new conditions of that action, evolve new series of the internal arrangements and changes of the substance under decomposition, and perhaps give efficient powers over matter as yet undecomposed. For the purpose of greater distinctness, he divides the inquiry into three heads. In the first, he treats of some new conditions of electro-chemical decomposition, and shows that that effect does not depend upon the simultaneous action of two metallic plates, since a single pole might be used to effect decomposition; in which case one or other of the elements liberated passes to that pole, and the other element to the other extremity of the apparatus, the air itself acting as a pole. In the second, he considers the influence of water in electro-chemical decomposition; and he combats the opinion that the presence of that fluid is essential to the process is erroneous, and shows that water is merely one of a very numerous class of bodies, by means of which the electric influence is conducted and decomposition effected. In the third, he enters at large into the investigation of the theory of electro-chemical decomposition; and after discussing at some length the various theories of different writers on this curious subject, he is led to consider the effect in question as produced by an internal corpuscular action, exerted according to the direction of the electrical current, and as being the result of a force either superadded or giving direction to the ordinary chemical affinity of the bodies present; that is, modifying the affinities in the particles through which the current is passing, so that they act with greater force in one direction than in another, and consequently cause them to travel, by a series of successive decompositions and recompositions, in opposite directions, so as to be finally disengaged at the boundaries of the decomposing body. Various experiments are detailed in corroboration of these views, which appear to explain, in a satisfactory manner, all the prominent features of electro-chemical decomposition.

10. "The Anatomy and Physiology of the Liver." By Francis Kiernan, Esq., M.R.C.S. Communicated by J. H. Green, Esq., F.R.S.

After giving a short account of the descriptions of Malpighi and other writers respecting the minute structure of the liver, the author proceeds to state the results of his own investigations on this subject. The hepatic veins, together with the lobules which surround them, resemble in their arrangement the branches and leaves of a tree; the substance of the lobules being disposed around the minute branches of the v ins like the parenchyma of a leaf around its fibres. The hepatic

veins may be divided into two classes: namely, those contained in the lobules, and those contained in canals formed by the lobules. The first class is composed of interlobular branches, one of which occupies the centre of each lobule, and receives the blood from a plexus formed in the lobule by the portal vein; and the second class of hepatic veins is composed of all those vessels contained in canals formed by the lobules, and including numerous small branches, as well as the large trunks terminating in the inferior cava. The external surface of every lobule is covered by an expansion of Glisson's capsule, by which it is connected to, as well as separated from, the contiguous lobules, and in which branches of the hepatic duct, portal veins and hepatic artery ramify. The ultimate branches of the hepatic artery terminate in the branches of the portal vein, where the blood they respectively contain is mixed together, and from which mixed blood the bile is secreted by the lobules, and conveyed away by the hepatic ducts which accompany the portal veins in their principal ramifications. The remaining blood is returned to the heart by the hepatic veins, the beginnings of which occupy the centre of each lobule, and when collected into trunks pour their contents into the inferior cava. Hence the blood which has circulated through the liver, and has thereby lost its arterial character, is, in common with that which is returning from the other abdominal viscera, poured into the vena portæ, and contributes its share in furnishing materials for the biliary secretion. The paper is accompanied by numerous drawings of preparations made by the author, of the minute structure of the liver, in which the different sets of vessels and ducts were injected in various ways.

The Society then adjourned over the Long Vacation to the 21st of November next.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1832-1833.

No. 14.

November 21, 1833.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer,
in the Chair.

A paper was read, entitled, "Historical Notice to the supposed Identity of the large mass of Meteoric Iron now in the British Museum, with the celebrated Otumpa Iron described by Rubin de Celis, in the Philosophical Transactions for 1786." Communicated in a letter from Woodbine Parish, jun., Esq., F.R.S., to Charles Konig, Esq., Foreign Secretary of the Royal Society.

The mass of iron in question was transmitted to Buenos Ayres, for the purpose of being manufactured into fire-arms, at the period when the people of that country declared themselves independent of Spain; but a supply of arms having in the meanwhile arrived, it was deposited in the Arsenal, and afterwards given to Mr. Parish, who transmitted it to England. Its identity with the mass of iron described by De Celis, though probable, is not exactly determined.

A paper was also read, entitled, "Observations of Nebulæ and Clusters of Stars, made at Slough, with a Twenty-feet Reflector, between the Years 1825 and 1833." By Sir John F. W. Herschel, K.H., F.R.S.

This paper contains the results of observations begun in 1825, and assiduously prosecuted till the commencement of the present year, for the purpose of reviewing the nebulæ and clusters of stars discovered by his father, the late Sir William Herschel, and also of extending his discoveries, and enlarging our knowledge of the nature and physical constitution of those remarkable and mysterious bodies. Since the recent improvements in the achromatic telescope, and the increased diligence of astronomers in surveying every part of the heavens, and detecting the passage of comets, the want of an extensive list of nebulæ has become continually more urgent; and hence the author was induced to supply, as far as he was able, that deficiency, which he has now attempted by simply stating the results of his own observations, in preference to waiting until he could present them to the Society in the more complete form of a general catalogue of nebulæ and clusters visible in this latitude. All the observations here given have been reduced to a common epoch, and arranged in the

order of right ascension : and in every case where the same object was observed more than once, all the observations relating to it have been collected together ; by which means they not only can be used as a catalogue for reference, but each result carries with it its own weight and evidence.

Great and various are the difficulties attending inquiries of this nature. Many of the nebulae present a surface so large and ill defined, that it is not always easy to determine where the centre of greatest brightness is situated. Vast numbers of the nebulae, indeed, are so extremely faint, as to be with difficulty perceived, till they have been some time in the field of vision, or are even just about to quit it ; so that the observations become hurried and uncertain. In those parts of the heavens where they are most crowded, their prodigious number, as well as their variety, and the interest they excite, render it scarcely possible to proceed with that methodical calmness and regularity which are necessary to ensure numerical correctness. It is also to be recollected, that it is only during the months of March, April, and May, that the richer parts of the heavens can be advantageously observed, and then only in the complete absence of the moon and of twilight. From all these causes conjoined, it will be readily understood, that a much greater latitude of error is incident to observations of nebulae than to those of stars.

The observations registered in this paper comprise 2500 nebulae and clusters of stars,—a number equal to that of those observed by Sir William Herschel : only about 2000, however, are common to both collections, the remaining 500 of the author's being new. Of these last, by far the greater proportion are objects of the last degree of faintness, only to be seen with much attention, and in good states both of the atmosphere and the telescope. The author generally made a sketch of any remarkable nebula that presented itself ; and these drawings accompany the paper. Among these are representations of some very extraordinary objects, which have not hitherto sufficiently engaged the attention of astronomers, and many of which possess a symmetry of parts, and a unity of design, strongly marking them as systems of a definite nature, each complete in itself, and subservient to some distinct, though to us inscrutable, purpose.

In an Appendix, the author enters into a detailed account of the manner in which the reductions have been executed, and how the numbers set down in the catalogue are concluded from those registered at the moment of observation. For effecting these reductions, he pursued a method materially different, and much more convenient and exact, than he employed to reduce his earlier catalogue of double stars.

Various remarks are next made on the figured nebulae. It often occurred to the author, to notice a peculiar state of the atmosphere, which is quite independent of fog or haziness, in which all large stars above the seventh magnitude appear surrounded with photospheres, of a diameter of two or three minutes, or even more, and exactly resembling those about some of the finer specimens of nebulous stars. These appearances come on suddenly, seldom last long, and disap-

pear as unexpectedly as they come : hence the inference is drawn, that the true cause of this phenomenon is atmospheric, and that it is perhaps connected with some highly rarefied material, disseminated in cloud-like, though invisible, masses in the very highest regions of our atmosphere, and possibly the same with that which, when ignited by the passage of electric currents, gives rise to many, if not all, the phenomena of the aurora borealis. Frequent instances occur of the proximity of minute stars to nebulae ; an appearance which naturally suggests the idea of their composing planetary systems : for the enormous magnitude of the nebulae, and its consequent probable mass, may, notwithstanding the rarity of its material, give it a gravitating energy, capable of retaining, in orbits three or four times their own diameter, and in periods of great length, small bodies of a star-like character.

Lastly, the author offers some remarks on the constitution of nebulae which have an elongated or elliptical form, of those which are double, and of those to which the epithets of *hairy* or *filamentous* have been applied ; and considers their relations to ordinary physical laws.

Anniversary Meeting, Nov. 30th, 1833.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The President delivered the following Address :

GENTLEMEN,

THE third anniversary of my election to this Chair affords me again the opportunity of expressing my grateful thanks for the kindness which I have continued to receive from you. I would willingly enlarge upon a topic which is so grateful to my feelings, were I not conscious that by so doing I should merely vary the form of phrases which the natural expression of my sentiments prompted me to use when I have before had the pleasure of addressing you, whilst the sentiments themselves remain not merely unchanged, but, I trust, likewise unchangeable. If I am thus brief, therefore, Gentlemen, in the public declaration of my acknowledgements, from a fear of being tedious by their too frequent repetition, I hope that you will not upon that account consider them the less sincere, or that the long experience which I have had of your support and co-operation has made me less sensible of their value.

When I last had the honour of addressing you, it was a source of pride and happiness to me to be empowered to announce to you the gracious intentions of His Majesty to continue to the Royal Society the Annual Grant of two Gold Medals, which had been previously conferred on the Royal Society by his Royal Predecessor.

It must be well known to you, Gentlemen, that these Royal Medals were not adjudged during the two first years that I presided over the Royal Society ; and as there exist many circumstances con-

nected with the original grant and distribution of those Medals, as well as causes leading to their temporary discontinuance, with which the Fellows may not be generally acquainted, I trust that I may be allowed to enter into some details respecting them.

His late Majesty King George the Fourth announced, towards the close of the year 1825, through the medium of the Secretary of State for the Home Department (Sir Robert Peel), his gracious intention of founding two Gold Medals, of the value of Fifty Guineas each, to be annually awarded as honorary premiums, under the direction of the President and Council of the Royal Society, in such a manner as should, by the excitement of competition among men of science, seem best calculated to promote the objects for which the Royal Society was originally instituted. This munificent gift of the Patron of the Royal Society was of course accepted by the President and Council with every expression of gratitude for so valuable an addition to their means of promoting the interests of science; and it was resolved that, in conformity with His Majesty's Commands, the Royal Medals should be adjudged for the most important discoveries or series of investigations completed and made known to the Royal Society in the year preceding the day of their award; that their presentation should not be limited to British subjects; and that His Majesty's effigy, if such should be the Sovereign's pleasure, should form the obverse of the Medals; and that two Medals from the same die should be struck upon each foundation, one of gold and the other of silver.

Upon proceeding to the distribution of the Medals, it was found that the limitation of time which these Resolutions fixed was of such a nature as to interfere most materially with the proper observance of the object proposed to be secured by their foundation; and the period was therefore, with His Majesty's sanction, extended to five years: in accordance with this arrangement the Medals continued to be awarded until the year 1830, inclusive, when the demise of His late Majesty took place, and in which year I had the honour of being elected to fill the Chair of the Royal Society.

Mr. Chantrey, to whom, in conjunction with Sir Thomas Lawrence, was intrusted the selection of the subject for the Medal, furnished the cast for the medallion of the head of His late Majesty, which was to form the obverse of it, while Sir Thomas undertook to compose the design for the reverse. Unfortunately, that distinguished artist, either from over-delicacy or over-anxiety to produce a work of art worthy of the object for which it was intended, or from that spirit of procrastination which was unhappily too common with him, delayed its execution from year to year, and died without leaving behind him even a sketch of his ideas respecting it, though the character of such a design as would be at once classical and appropriate to the purpose, was the subject of frequent conversation, and even of favourite speculation with him. From these and other causes, to which it is not necessary for me now to advert, it arose, that, at the demise of His late Majesty, although the adjudication of ten Medals had been formally made and announced from the Chair

of the Royal Society, not even the dies, much less the Medals, were forthcoming for the purpose of distribution to the various distinguished persons, some of them foreigners, to whom they had been awarded.

It cannot be necessary for me to impress upon you, Gentlemen, that the non-completion of an engagement so solemnly entered into with the whole republic of men of science, would have brought discredit not merely upon the Royal Society, but upon the personal honour of a Monarch of this country, whose name it is our especial duty as Fellows of the Royal Society, to hand down unsullied to posterity, as our munificent Patron and benefactor; and as no funds had been placed at the disposal of our Treasurer, nor in the hands of any other ostensible person to meet the very heavy expenses which must be incurred for cutting the dies and furnishing the Medals already awarded, I felt it to be my duty, when I succeeded to this Chair, to recommend to the Council the suspension of any further adjudgment of the Medals until I could have an opportunity of ascertaining the nature of the commands which had been issued concerning them by the late Sovereign through his official advisers or otherwise, and also of taking the pleasure of His present Majesty respecting their continuance in future, and the conditions to which they should be subject. These inquiries terminated in the most satisfactory manner. On a proper application to those who were intrusted with the ultimate arrangement of His late Majesty's affairs, prompt measures, as far as lay in their power, were adopted for the immediate fulfilment of every pledge which it was conceived had been given to the Royal Society and to the public at large in the name of George the Fourth.

The dies for the Medals upon the old foundation are now completed, and ready for distribution; they bear upon the one side the likeness of His late Majesty, while the reverse represents the celebrated statue of Sir Isaac Newton, which is placed in the chapel of Trinity College, Cambridge, with such emblematical accompaniments as seemed best calculated to indicate the magnificent objects of the researches and discoveries of that great philosopher, whose peculiar connexion with the Royal Society forms the most glorious circumstance in its annals.

After having settled that part of the business, and apprized the King of my success, I then ventured to petition His Majesty for the continuance of that protection and munificence which the Royal Society had ever experienced from His Illustrious Predecessors. The Sovereign, with that just and enlightened zeal for the promotion of every object allied with the honour and prosperity of this country, which as a loyal subject I acknowledge with gratitude, while as an affectionate brother I recognise it with pride, acceded at once to my request, accepted the charge devolved upon him by the demise of the late King, and ordered, in consequence, that a fresh die should be cut, and that his effigy should form the obverse side of the medal. This work also is completed. All the dies have been executed by Mr. Wyon with such boldness of outline, depth, and deli-

cacy of finish, as do him the highest credit: and I trust that the medals will be considered in every way worthy of the exalted rank and dignity of the Illustrious Personage in whose name this mark of Royal favour is intended to be conferred.

I am well aware that a diversity of opinion exists respecting the advantages which are likely to be conferred upon Science by a frequent distribution of medals. It is said that they must either confirm or contradict the judgement which has been either already pronounced, or which posterity will most certainly hereafter pronounce, upon the merits, pretensions, and influence of the discoveries or series of investigations which such medals are designed to commemorate: that in the first case they can confer no additional honour upon their author, whose rank has already been ascertained and fixed by the sentence of a higher tribunal, while, in the second, they can only tend to compromise the character of the scientific body by whose advice they are conferred. It is true that I would not claim infallibility for the united judgement of any association, or of any body of men, however eminent their scientific rank may be: but it is the peculiar privilege of the great masters of Science, (and more particularly so when acting or speaking as a body,) to be able to anticipate, though not without the possibility of error, the decision of Posterity, and thus to offer to the ardent cultivator of Science that highest reward of his labours, as an immediate and well assured possession, which he might otherwise be allowed silently and doubtfully to hope for, but never be permitted to see realized: and though some powerful minds might be content to entrust the complete developement of their fame to the fulness of time, and might pursue their silent labours under the influence of no other motives but such as are furnished by their love of truth, the gratification derived from the discovery of the beautiful relations of abstract science, or from the contemplation of the agency of a Divine Mind in the harmonies and constitution of the physical world, yet it is our duty and business to deal with men as we find them constituted, and to stimulate their exertions by presenting to their view honourable distinctions attainable by honourable means; to assure them that the result of their labours will neither pass unnoticed nor unrewarded; and that there exists a tribunal to which they may appeal, or before which they can appear, whose decision is always for honour, and never for condemnation.

It is for these reasons, Gentlemen, that I feel myself justified in expressing my opinion that the power possessed by your Council of conferring honorary rewards is a most salutary power, provided it be exercised boldly, impartially and diligently; and that it may greatly promote the taste for scientific pursuits in this country, by presenting a more immediate prospect than would otherwise exist, of a public and distinguished recognition of any valuable discovery, or of the completion of any important and laborious course of investigation.

I had occasion, Gentlemen, when I had last the honour of addressing you, to remark that there were many circumstances in the con-

stitution of society in England, and perhaps in the form and working of our Government, which were unfavourable to the cultivation of Science as a distinct and, as it were, a Professional employment. Though many of the causes of this evil, if so it may be considered, are too deeply seated to be reached by any legislative enactment, and though its existence may be the result of a system, the general effects of which are favourable to the interests and happiness of society at large, yet I think it is the duty of a wise Government to neglect no opportunity of promoting, by liberal encouragement, the developement of the intellectual as well as of the physical resources of a nation. Without venturing to give an opinion from this Chair, which it would ill become me to do, whether the various Administrators of the Government of this country, for more than a century past, have adequately fulfilled this duty, by animating individuals to the cultivation of Science by all the influence at their command, I rejoice and feel proud at finding myself at full liberty to give free utterance to the language of my feelings when speaking of the Royal Patron of the Royal Society, who has shown himself in this as in every other capacity, the Friend, the Protector, and the Promoter of whatever is dignified with the name and character of Science in this country. The King, Gentlemen, is the Fountain of Honour; and although His Majesty has been graciously pleased to authorize the President and Council of the Royal Society to act as his Official Advisers, in awarding his Royal Medals, he will not on that account regard them as less worthy of being considered as the immediate gifts of his Royal bounty, and as the honourable symbols of his Royal approbation.

It will be my first duty, Gentlemen, to distribute the Ten Royal Medals which have been already adjudged during the life-time of His late Majesty, to Philosophers who are amongst the most illustrious in this country or in Europe: they form a glorious commencement of a philosophical chivalry, under whose banners the greatest amongst us might feel proud to be enrolled; and though it may appear presumptuous in me to hope that a constant succession of associates can be found, either at home or abroad, who shall be considered worthy of being ranked with those noble Founders of this Order, yet I am confident that the Council of the Royal Society will feel an honourable pride in maintaining the character of the Body whose Members are to be constituted by their choice.

In proceeding now, therefore, to call your attention, Gentlemen, to the series of great men to whom those Medals have been awarded, I shall not presume to state in detail the specific grounds upon which the decisions of your Council were founded, but confine myself to little more than their enumeration in the order of time, feeling that it would be unbecoming in me to attempt to assign them those stations which they either have taken, or are destined hereafter to take, in the temple of fame.

The first name upon the list is that of DR. JOHN DALTON, a venerable Philosopher, whose developement of the Atomic Theory and other important labours and discoveries in physical science have, at the

eleventh hour, (I blush to own that it was not earlier,) first abroad, and secondly at home, secured him that public recognition of his scientific rank to which he has long been entitled. With him, Gentlemen, *posterity* may be said to have already commenced, and though full of years and honour, I rejoice to hear that he still retains the same zeal and vigour in the pursuits of science which have carried him forwards from his earliest youth in his career of discovery, in spite of all the discouragements of confined means and of the most laborious and depressing employments. It gives me great pleasure to learn that His Majesty has lately expressed his Royal approbation of his services to science by the grant of a pension, if not commensurate with his services, at least as considerable as the severity of existing regulations will allow; though I cannot refrain from expressing on this occasion my regret at the very narrow limits within which the munificence of the King and the generosity of the Nation should be confined.

The second Medal for the same year was awarded to MR. IVORY, the first of our mathematicians who transplanted to this country the profound analytical science which LaGrange, Laplace, LeGendre, Gauss and others upon the continent, had applied to the most important and sublime physical inquiries. The dignity of such investigations has not suffered by the association of Mr. Ivory's name with them, and the Transactions of the Royal Society present frequent and honourable records of his valuable labours. It is, however, a gratifying circumstance to find that Mr. Ivory is no longer a solitary cultivator of these sublime sciences; but that an English School, of which he may be considered as the Father, is now rising, and must continue to rise, whilst it boasts of such masters as our Herschels and Airys, our Lubbocks and Hamiltons, and looks forward to such disciples as they are likely to form.

The Medal which was awarded to SIR HUMPHRY DAVY was a tribute of respect to that great Philosopher towards the conclusion of his labours. He had already retired from the Chair of the Royal Society, under the admonition of those infirmities which were destined too speedily to terminate his valuable life; and the Council availed themselves of the first opportunity of marking their sense of the honour which he had conferred upon his country by his brilliant electro-chemical and other discoveries, by awarding to him, as a Fellow, that Medal which, from natural feelings of delicacy, they could not have offered to their President.

In the following year a similar tribute of gratitude and respect was paid to DR. WOLLASTON, who had so long honoured the Royal Society by his services and his scientific contributions, and who, towards the close of his life, had augmented its means of usefulness by his liberality.

The fame of these two illustrious men is established upon too firm a basis to require or receive additional strength or permanence from any honours which we can pay to their memories; but there are some who were connected with them by the tenderest ties of kindred and affection, who are in part the depositories and inheritors of

their honours: these may cherish the possession of such monuments, as recording the reverence and respect of their contemporaries and fellow-labourers. To their hands, therefore, we commit them, as our last public offering to their memories. *Illi habeant secum, servantque sepulchro.*

The two other Medals for the corresponding years were awarded to two distinguished foreign Astronomers. The first, to PROFESSOR STRUVE, of Dorpat, who is so justly celebrated for his numerous and valuable observations of double stars,—a department of astronomy which is daily acquiring an increase of interest and importance, from the new and extensive views which it is beginning to open to us of the constitution of the remoter parts of the universe, and of the laws which seem to govern some at least of the periodical changes which they are undergoing. The second, to PROFESSOR ENCKE, of Berlin, the greatest of modern astronomical calculators, who first determined and predicted the motion of the comet which is justly signalized by his name, with an accuracy approaching to that which before belonged to the ephemerides of the planets only; and who still more has subjected the discrepancies between its tabulated and observed places to so accurate an analysis as to make them the foundation of the most novel and unexpected speculations respecting the existence of a resisting medium, which is capable of sensibly affecting the motions of those extraordinary bodies which obey the laws of gravity, at the same time that they seem to present few or none of those characters with which our notions of matter and substance are commonly associated.

The Medals for the years 1829 and 1830 were adjudged to SIR CHARLES BELL, to PROFESSOR MITSCHERLICH of Berlin, to SIR DAVID BREWSTER, and to M. BALARD of Montpellier.

To the first, for his elaborate experiments and discoveries relating to the nervous system, which place him in the highest rank of the physiologists and anatomists, not merely of this country, but of Europe.

To the second, for his theory of isomorphism, one of those great generalizations in the sciences of chemistry and crystallography which are reserved for men of large and extensive views, and which may be considered as constituting a great epoch in their history.

To the third, for his discoveries relating to the polarization of light, the most important laws of which he determined; forming one of those great series of experimental investigations relating to the properties of light and the optical properties of crystals which are unrivalled, since the time of Newton, for their variety, their delicacy, and perhaps also for their theoretical importance.

To the last, for a singularly successful and well developed example of chemical analysis, which terminated in the discovery of a new, and hitherto undecomposed body, Bromine.

I now come to the consideration of the Medals upon the Foundation of His present Majesty; and it is the King's pleasure that the President and Council of the Royal Society should be considered as his official advisers, in the award of an honour which emanates immediately from himself. His Majesty has also been graciously pleased

to prescribe the general Rules and Principles which shall regulate their distribution hereafter. The King has therefore commanded that they shall be adjudged annually, and that the award shall be announced on the day of the Anniversary Meeting of the Royal Society; that the Memoirs which shall be entitled to receive them, whether composed by Foreigners or by Englishmen, shall be communicated to the Royal Society; and that the *general* subject matter of such Memoirs shall be prescribed and announced by the Council at least three years preceding the day of their award: and also, that for the present and the two following years, the principle of their distribution shall be the same as that which has hitherto been adopted, with the additional condition, that the succession of branches of science which shall be selected as entitled to these rewards, shall be the same as that which shall be hereafter followed when the cycle of their regular distribution begins.

The selection of the subjects which should compose this cycle was left to the Council of the Royal Society, who have made such a choice as seemed to them best calculated to comprehend every department of science and to prevent the jealousies which might arise from the recurrence of similar subjects in immediate or too close succession: the subjects themselves and their periodical order (determined by lot) are as follow:—

1. Astronomy.
2. Physiology, including the Natural History of Organized Beings.
3. Geology and Mineralogy.
4. Physics.
5. Mathematics.
6. Chemistry.

In conformity with these Regulations, which form the existing law for the distribution of the Royal Medals, they have been awarded for the current year to PROFESSOR DE CANDOLLE, of Geneva, for his numerous and valuable researches and investigations in Vegetable Physiology, as detailed in his Work, entitled "*Physiologie Végétale*," published in the year 1832; and to SIR JOHN FREDERICK WILLIAM HERSCHEL, for his Paper "*On the Investigation of the Orbits of Revolving Double Stars*," inserted in the Fifth Volume of the Memoirs of the Royal Astronomical Society.

The science of Vegetable Physiology has at all times presented extraordinary difficulties, and although it has employed the talents and the industry of a great number of philosophers, from the earliest period, little progress has been made in obtaining an exact knowledge of the minute organization of plants, and of the mode in which their functions are exercised, at least, when compared with the great advance which has taken place in the analogous sciences which relate to the comparative anatomy and physiology of animals.

The structure of vegetables, in consequence of its minuteness and intricacy, is involved in the greatest obscurity; its investigation requires the application of powerful microscopes, and is liable to all the fallacies peculiarly incident to such observations: and the greater part of vegetable physiology being dependent on the full and accurate

knowledge of that organization, is exposed to the same causes of uncertainty. But the progress of this department of science has suffered less from the want of accurate and sufficiently multiplied observations, than from the absence of a well-compacted and consistent theory to connect them together; and it was chiefly with a view to supply this great deficiency that the admirable work of Professor de Candolle was written, which has been selected by the Council as justly entitled to one of the Royal Medals. There is, in fact, no branch of botanical science which has not been greatly benefited by his valuable labours: his *Théorie Élémentaire de la Botanique* and his *Organographie Végétale* have made most important additions to our knowledge of descriptive botany, whilst in his *Physiologie Végétale*, by a most careful analysis and examination of the influence both of external and internal physical agents upon the organs of plants in the great functions of their nutrition and reproduction, by tracing them throughout the whole course of their operations, and by connecting their results with the well-known and well-established deductions of chemistry and other sciences, he has shown that he is also entitled to claim the rank and distinction of an inductive philosopher of a very high order.

The mention of the name of the second of these distinguished Philosophers to whom the Royal Medals for the present year have been adjudged, recalls my attention to the circumstances under which he has recently quitted his home and his country to pursue his labours in another hemisphere. He has devoted himself, as you well know, for many years at least, as much from filial piety as from inclination, to the examination of those remote regions of the universe into which his illustrious father first penetrated, and which he has transmitted to his son as an hereditary possession, with which the name of Herschel must be associated for all ages. He has subjected the whole sphere of the Heavens within his observation to a repeated and systematic scrutiny. He has determined the position, and described the character of the most remarkable of the nebulae. He has observed and registered many thousand distances and angles of position of double stars; and has shown, from the comparison of his own with other observations, that many of them form systems whose variations of position are subject to invariable laws. He has succeeded, by a happy combination of graphical construction with numerical calculations, in determining the relative elements of the orbits which some of them describe round each other, and in forming tables of their motions; and he has thus demonstrated that the laws of gravitation, which are exhibited as it were in miniature in our own planetary system, prevail also in the most distant regions of space: a memorable conclusion, justly entitled, by the generality of its character, to be considered as forming an epoch in the history of astronomy, and presenting one of the most magnificent examples of the simplicity and universality of those fundamental laws of nature by which their Great Author has shown that He is the same to-day and for ever, here and everywhere.

A discovery like this, which we are this day called upon to commemorate, forms a noble, but I trust only temporary termination

to Sir John Herschel's European labours. He has long contemplated a voyage to the Cape of Good Hope, as a favourable station for observing the constellations of the Southern Hemisphere, and the magnificent nebulae which it contains; and when we consider the space-penetrating power of his instruments, such as has never yet been brought to bear upon them; his skill and long experience and systematic diligence as an observer; his perfect familiarity with the class of phenomena which are to be observed; his sagacity in interpreting and disentangling the most complicated appearances; and his profound knowledge of physical as well as practical astronomy, we may look forward to a harvest of discoveries, such as will not only extend the existing boundaries of science, but add to the lustre of a name which is known and revered in every region to which European civilization has reached.

It has been said that distance of place confers the same privileges as distance of time, and I should gladly avail myself of the privilege which is thus afforded me by Sir John Herschel's separation from his country and friends, to express my admiration of his character, in stronger terms than I should otherwise venture to use; for the language of panegyric, however sincerely it may flow from the heart, might be mistaken for that of flattery, if it could not thus claim somewhat of an historical character: but his great attainments in almost every department of human knowledge, his fine powers as a philosophical writer, his great services and his distinguished devotion to science, the high principles which have regulated his conduct in every relation of life, and, above all, his engaging modesty, which is the crown of all his other virtues, presenting such a model of an accomplished philosopher, as can rarely be found beyond the regions of fiction, demand abler pens than mine to describe them in adequate terms, however much inclined I might feel to undertake the task. That he may live to accomplish all the objects which have induced him to transport himself to another continent, and that he may long survive his return to witness the respect, reverence and gratitude of his countrymen, is my earnest prayer, in which I am quite sure that you, Gentlemen, will cordially join.

It now becomes my painful duty to call your attention to the names of those Fellows and Foreign Members whom the Royal Society has lost during the last year.

SIR JOHN MALCOLM was born in the year 1769, a year remarkably fertile in the production of great men*. He was one of a family of seventeen children, which enjoyed the singular distinction of having three of its members created Knights of the Bath in the same year. At the early age of thirteen he was sent to India as a Cadet, and learnt his first lessons of military service in the celebrated wars of the Mysore; and during an almost uninterrupted residence of nearly forty years, he was employed both in civil and military duties, frequently of great importance and difficulty, in almost every part of Central India; and it was chiefly owing to the opportunities afforded by this long intercourse with the natives of all classes and nations,

* Napoleon, Wellington, Cuvier, &c.

aided by the system of carefully recording his observations of their manners and customs, and by his perfect knowledge of their languages, that he was enabled to acquire the most intimate acquaintance with their habits, their feelings and their prejudices, at the same time that he secured, in a very uncommon degree, their confidence and respect by his strict impartiality, and by his considerate attention to their wants and their interests.

He was twice sent as Ambassador to Persia, where he conducted negotiations of great delicacy and difficulty in such a manner as to maintain the honour, at the same time that he secured the interests of the Government which he represented: he was, in fact, eminently qualified for the discharge of such a duty by his profound knowledge of the Persian language and literature, and by the conformity of his own manners with those of that lively and polished nation. Nor were the fruits of his mission political merely, inasmuch as they led to the production of his *History of Persia*, a work of great research and of standard value; to his *Persian Sketches*, so remarkable for their wit and vivacity, and, I believe, likewise for the truth of the pictures of manners which they furnish; and also to a volume of Poems, which display no inconsiderable powers of versification.

Sir John Malcolm was a voluminous writer, and amongst other works may be particularly mentioned his *Political History of the Government of India, from the year 1784 to the Present Time*; his very interesting *Sketch of the Sikhs*, and his *History of Central India*. In all his writings he has shown himself to be the friend of the native population, and the zealous advocate of a system of government such as would reconcile the interests of the governed with those of the governors: and though he has very clearly demonstrated that our Indian Empire must be progressive in order to be permanent, and that external attacks upon it must not only be repelled, but the means of renewing them either greatly weakened or altogether removed, yet he stigmatizes with just reprobation the commencement or continuance of wars of conquest merely, which are not rendered necessary by previous and adequate provocation. Upon all such subjects Sir John Malcolm was eminently entitled to pronounce an authoritative opinion, from his great experience, both military and civil, and from his almost unequalled knowledge of the political interests and relations of all the various nations who compose or border upon our Indian Empire.

Sir John Malcolm returned to England in 1822: in 1827 he was appointed Governor of Bombay and Central India. He retained this important situation for three years, when he was recalled for the purpose of taking part in the discussions which were likely to arise upon the renewal of the East India Company's Charter. He was shortly after his return elected Member of Parliament for Launceston; but the questions which almost entirely absorbed the attention of Parliament and of the public at that period were not calculated for the favourable display of his peculiar powers. His last public address was made at a meeting in London in honour of his illustrious

countryman Sir Walter Scott, of whose genius and writings he was an enthusiastic admirer: on the following day he was attacked by paralysis, from which he never recovered; and he died at his house in London on the 31st day of May last.

Sir John Malcolm was tall and commanding in his person; his manners were remarkably free and unconstrained, and his conversation rapid and animated; and notwithstanding his long and intimate intercourse and association with Oriental people and Oriental languages and with scenes of life altogether different from those in which his earlier boyhood had been passed, yet he continued to speak with the accent of his countrymen, and to remember their national traditions with all the vividness and to recite their national poetry with all the enthusiasm, which characterize our earliest and deepest impressions. As a father, a husband and a brother he was eminently kind and affectionate; and few persons have been more generally beloved by their friends for their social virtues, or more respected and revered for their great talents and attainments and for their eminent public services.

I observe with pleasure that a monument, from the chisel of Mr. Chantrey, is to be erected to his memory in Westminster Abbey, for which ample funds have been provided by the almost spontaneous contributions of his friends; and it is worthy of remark that amongst the subscribers is to be found the name of an Eastern Potentate, the Pacha of Egypt, the founder of a great empire, and still more distinguished for his triumphs over Eastern prejudices, who became acquainted with Sir John Malcolm upon his return from Bombay, and who has most gladly availed himself of this opportunity of expressing his respect for the memory of his friend.

MR. WILLIAM MORGAN was the author of several papers in our Transactions, chiefly upon the subject of the value of reversions contingent upon different cases of survivorship. For two of these papers, printed in 1788 and 1789, he received the Copley Medal. He was one of the first authors who rejected altogether the hypothesis of the equal decrements of life which had been introduced by De Moivre, partly from the want of correct tables, and partly for the purpose of simplifying the formulæ employed in the calculation of contingent reversions; and he showed in what manner such questions could be practically solved with reference to the real probabilities of life. Mr. Morgan was the nephew of the celebrated Dr. Price, whose memoirs he has written, and some of whose works he has edited; and he partook largely, at one period at least, of some of the political and financial opinions of that ardent character, particularly relating to the dangers of a national bankruptcy from the rapid increase of our National Debt. He was appointed early in life, chiefly by his uncle's influence and recommendation, to the situation of Actuary of the Equitable Assurance Company, which he continued to hold for nearly sixty years; and the unexampled wealth and prosperity of that great establishment may be in a great degree attributed to the confidence inspired by the correct principles of calculation and of management which he introduced: and though he

was exposed towards the close of life to many attacks and much opposition, in consequence of his too rigid adherence to a system which might be calculated to do injustice to some classes of insurers, yet no small indulgence is due even to the prejudices of a man who had done so much service to society, by establishing upon a firm basis the security of establishments which act as safeguards against the fluctuations and vicissitudes of life, and which thus encourage habits of providence and of foresight amongst the higher and middle classes of the community.

MR. THOMAS ALLAN, an eminent citizen of Edinburgh, was the author of a work on Mineralogical Nomenclature, and of several papers on geology and mineralogy in the Transactions of the Royal Society of Edinburgh, and elsewhere. He was greatly distinguished for his accurate knowledge of mineral species and their varieties, and of all the delicate and minute distinctions of external characters by which they are separated from each other; and his collection of minerals has been justly celebrated for its great extent and perfect arrangement. In the year 1812 he joined Sir George Steuart Mackenzie in an Excursion to the Faroe Islands, where he greatly enriched his collection, particularly in zeolites. This expedition was undertaken for the purpose of ascertaining whether, in a Trap Country, where no traces of *external* volcanoes existed, any thing similar to the peculiar features of the rocks of Iceland was to be found: and his Account of the Mineralogy of these Islands, in which his object has been to describe, without relation to theory, whatever appeared to him interesting in a geological point of view, was read before the Royal Society of Edinburgh in the beginning of the following year, and printed in the seventh volume of their Transactions. He adopted in early life the opinions of Dr. Hutton, though his papers on some points in geology in the neighbourhood of Edinburgh, and in the environs of Nice, show him to have been an accurate and an unprejudiced observer. He was a person of active habits and character, a liberal supporter of public charities and useful institutions, and an ardent and even enthusiastic friend of all the schemes for the improvement and decoration of his own magnificent and picturesque metropolis.

DR. WILLIAM BABINGTON was a distinguished physician in the City of London. He was formerly a lecturer on materia medica and on chemistry at Guy's Hospital, and he was the author of a Systematic Arrangement of Minerals, founded upon a joint consideration of their chemical, physical and external characters; and also of other works, of less importance, upon mineralogical arrangement. He was the active and disinterested friend of science and of men of science, from the time of Priestley to that of Sir Humphry Davy; and though the absorbing duties of a laborious profession prevented his taking a leading part in original inquiries, he was well acquainted with the existing state of knowledge, particularly in geology, physiology and chemistry. He was one of the first founders of the Geological Society; and the earliest meetings of that distinguished body, which has contributed so powerfully to the advancement of geological know-

ledge, were held at his house. He was a person of great simplicity of manners, a warm and active friend, zealous in the promotion of objects of charity and usefulness, and in the practice of his profession singularly kind to the poor.

The death of LORD DOVER in the course of this year excited an unusual degree of public sympathy and sorrow, from his youth and high birth, his domestic virtues, and perhaps also his domestic happiness, his unsullied public character, his cultivated taste for the arts, and his liberal and enlightened patronage of artists, and most of all from the promise of the highest literary distinction afforded by his very interesting historical memoirs and other literary productions. Such qualities and attainments, whilst they give dignity to all who possess them, acquire a peculiar grace and lustre when found in those classes of society in which the possession of rank and wealth separate altogether the pursuit of knowledge and of fame from all taint of a suspected union with the desire of mere personal aggrandizement.

THE REV. BEWICK BRIDGE, Fellow of St. Peter's College, Cambridge, obtained the highest mathematical honours in his own academical year. He was for many years Mathematical Professor in the East India College at Haileybury, and was the author of several elementary works on different parts of mathematics, which are remarkable for their judicious adaptation to the capacities of ordinary students, by the union of simplicity and fulness in the developement of first principles,—a species of merit which those only can duly estimate whose experience in education has shown it to be very rarely attained. Mr. Bridge was a person of great benevolence, who devoted his life and fortune to the promotion of objects of charity and public utility, and whose purity of character and kindness of heart secured him the affectionate attachment of a large circle of friends.

CAPTAIN LYON became first known to the public from his having accompanied the late Mr. Ritchie in his journey into the interior of Africa. His companion died at Moorzouk, and after encountering the ordinary succession of sufferings and dangers which characterize the melancholy records of African discovery, he succeeded in effecting his return, and published a very modest and interesting journal of his travels. He afterwards accompanied Captain Parry in the second voyage to the Arctic Regions, as commander of one of the two ships which composed that expedition. After his return he was chosen, from a knowledge of his enterprising and energetic character, to conduct a party of English miners to Zacatecas and Bolaños in Mexico, and to undertake the management of the first of these mining establishments: and though he continued there for a short time only, being compelled by domestic circumstances to return to England, his services were of such a kind as to produce the most important results. His Mexican adventures form a narrative full of interesting, amusing and instructive details. He was afterwards chosen by the Brazilian Company to superintend the celebrated gold mines at Gongo Soco, in the province of Minas Geraes, which under his management became so productive, as fully to vindicate and re-

deem the character of South American mining speculations. Upon quitting their service he engaged in mining adventures of his own; and it was in returning to England, in consequence of an accidental injury which he received in the course of his operations, that he died at sea, in the thirty-seventh year of his age.

MR. JOSHUA BROOKES was for more than forty years a distinguished teacher of anatomy, and it is said that during the course of his life he had superintended the anatomical education of more than seven thousand pupils. He had formed a Museum of human and comparative anatomy, which was second only in extent and value to the Hunterian Collection, and to which he gave the most ready and liberal access both to his pupils and to the public. To the completion of this museum, and to the instruction of his pupils, he devoted the whole of his time and of his income; and it was a melancholy circumstance that he should have been compelled towards the close of his life, when his health, and with it his sources of income were declining, from the pressure of pecuniary difficulties, to consent to the sale of his museum. The dispersion of this collection was to him a source of the most poignant distress; and the latter years of a long life which had been devoted with singular disinterestedness to the public service, were embittered at once by the pressure of poverty and the despondency occasioned by the annihilation of those hopes of having raised a lasting monument to his fame, which had formed the great object of his ambition.

LIEUTENANT-COLONEL JOHN BAILLIE went to India as a Cadet in 1791, and from the commencement of his residence he devoted himself with great diligence to the study of the Oriental languages. Upon the establishment of the College of Fort William, in 1800, he was appointed Professor of the Arabic and Persian languages, and of the Muhammedan law, a situation which he continued to fill with great credit and distinction for several years. He was the author of *Tables elucidatory of a Course of Lectures on Arabic Grammar*, of *A Collection of the original Texts of the five most celebrated Grammars of the Arabic Language*, and of *A Translation from the Arabic of a Digest of the Muhammedan Law*, of which one volume only out of four was published. His Oriental studies appear to have terminated upon his appointment as Resident at Lucnow, where he continued for several years. He quitted India in 1818, and in 1823 he was appointed a Director of the East India Company. Colonel Baillie was one of the founders and most active supporters of the Royal Asiatic Society; and he represented his native town, Inverness, and its contributory burghs, in two successive Parliaments. His collection of Persian, Arabic, and other Oriental Manuscripts is said to have been one of the most extensive and valuable that was ever brought to this country.

MR. JOSEPH WHIDBEY was for nearly fifty years a Master in the Navy, and had been one of the companions of Vancouver in his voyage round the world. He was a person of great practical knowledge and skill, and possessed of more than ordinary general attainments; and he was in consequence selected by the Government to

superintend, under the direction of the late Mr. Rennie, the execution of that great national work, the Breakwater at Plymouth. He was the author of three papers in our Transactions: one on the means adopted for raising the Dutch frigate *Ambuscade*, which had been sunk at the Nore; and the other two on certain fossil bones discovered in the limestone quarries at Oreston, near Plymouth.

ADRIEN MARIE LE GENDRE, one of our Foreign Members, and one of the most illustrious analysts in Europe, was born in Paris in 1752, and died on the 10th of January last, in the eighty-first year of his age. After the completion of his studies at the Collège Mazarin, he devoted himself to mathematical and scientific pursuits, which he continued, with singular perseverance and industry, for the remainder of his life. At the age of thirty he gained the two prizes proposed by the Academies of Berlin and Paris; the one for a memoir on the motion of projectiles in a resisting medium, and the other for a memoir on the attraction of spheroids upon any external point whatever. It was this second memoir which gained him, in the following year, a place in the Academy, as the successor of D'Alembert, and which attracted in a peculiar degree the attention of mathematicians. The problem which it treated was one of the greatest importance and difficulty, particular cases only of which had been successfully treated by Newton, MacLaurin and Clairaut, but which he attacked in all its generality, and mastered its difficulties "sword in hand," to use the expressive language of Lagrange, when speaking of this admirable memoir. An important proposition discovered by Laplace led to a second, and a happy substitution, proposed and applied by Mr. Ivory, to a third resumption of this problem, which has finally terminated in such an organized system of approaching its difficulties, that it has lately been reduced to the order of those propositions which are included in the higher class of elementary books*.

It was in the course of his researches upon the attraction of spheroids that his attention was first drawn to the subject of elliptic integrals, concerning which his first memoir was published in 1786. He continued to pursue this most interesting and difficult branch of analysis in a succession of works, for a period of nearly forty years, and had finally collected his entire labours upon it in two volumes quarto, which he published in 1827, forming a vast treasure of analytical knowledge. He had hitherto laboured in this field without a colleague and without a rival, when two young analysts of singular genius and boldness, M. Abel, of Christiania in Norway, and M. Jacobi, of Königsberg, announced, almost simultaneously, the discovery of propositions which have led to an immense extension of this theory. LeGendre, with a nobleness of character which can only result from the most disinterested love of truth, was the first to welcome the appearance of these illustrious strangers upon his own territories, to make known the full importance of their discoveries, and to develop all their consequences; and although already arrived at an

* Poisson, (*Traité de Mécanique*, second edition,) who has obtained an expression for the attraction under a finite form.

extreme old age, he commenced and finished, with all the vigour and activity of youth, a third volume, expressly devoted to the discussion and classification of these *ultra-elliptic* functions, and to point out their analogy with, and relation to other classes of transcendents which he had himself already considered, or to which they would naturally lead.

M. LeGendre was the author of a justly celebrated treatise or essay on the Theory of Numbers, which first reduced the numerous and disconnected discoveries of Fermat, Euler and Lagrange to systematic order. He was the proper author, amongst many other discoveries, of the *law of reciprocity* between any two prime numbers, one of the most fertile and important in this theory, though its complete establishment was reserved for Gauss, whose work on this subject has gained him so just a reputation. Notwithstanding, however, the labours of these great men, this most important department of analysis still continues to be too much insulated, both in its form and its treatment, from the other branches of algebra, though much has been done to reunite them by the very valuable and original researches of that distinguished analyst M. Libri, of Florence, who has been recently naturalized in France, and who has succeeded M. LeGendre in his place in the Institute.

The work of M. LeGendre, on Geometry, has enjoyed a singular reputation, and has been most extensively used, particularly on the continent of Europe, in the business of education. It may be doubted, however, whether this work has altogether merited the high character which it has obtained: it has rather increased than cleared away the difficulties of the theory of parallels, which have so long embarrassed the admirers of ancient geometry and of the Elements of Euclid; and it has not succeeded, at least in any essential degree, in adding to the simplicity of the demonstrations, or to the clear and logical connexion and succession of the propositions of that unrivalled and unique elementary work, which has alone maintained its place amongst all civilized nations for more than two thousand years. It is proper, however, to observe that the notes appended to this work are full of valuable and original remarks, and are justly celebrated for the elegance of the demonstrations which they furnish of many important propositions.

M. LeGendre was the author of many other works and memoirs, containing many valuable series of investigations, and very important discoveries. He first attacked the great problem of the determination of the orbits of comets by general methods, which display all the resources of his analysis; though astronomers have not found it expedient to make use of his methods in the actual calculation of their elements, which is the only proper test of their practical value, though it may not be decisive of their theoretical perfection. He was the author of the method of *the least squares of the errors*, for the purpose of determining the most probable mean amongst the results of a great number of observations, of which such extensive use is now made in practical astronomy: a celebrated and most useful theorem

in geodesy goes by his name; and there are few departments of analysis or of dynamics which have not been benefited by his labours.

M. LeGendre was associated with Méchain and Cassini in the operations which were instituted in 1787, and finished in 1790, for the junction of the meridians of Paris and London. He was one of the three Members of the Council nominated for the purpose of introducing the new metrical system into France in 1795, and he constructed the formulæ employed for the calculation of the tables for the centesimal division of the quadrant. He was nominated, both during the Imperial and subsequent Government, to various public employments, chiefly, however, of an honorary nature, requiring no great sacrifice of time or attention,—a fortunate circumstance, when it is considered to what important labours the leisure of his long life appears to have been devoted.

The next name which I feel called upon to notice is that of FRANCISCO DE BORJA GARCÃO STOCKLER, BARON DA VILLA DA PRAIA, a Lieutenant-General in the Portuguese army, and formerly Secretary of the Academy of Sciences of Lisbon: he was the author of several Papers in the Transactions of the Lisbon Academy, chiefly on subjects connected with the developement of functions, and also of a volume of Poems. In 1795 he published his *Methodo dos Limites*, and in 1824 his *Methodo inverso dos Limites*. In this latter work, written late in life, he adopted the opinions of the well-known Hoene de Wronski, which led to its rejection by the Academy of Lisbon, upon the report of two Academicians, when it was offered to them for publication. His works are not of a kind to exercise much influence upon the progress of science, and some of them are examples of the danger of dealing with formulæ of such great generality that their proper import and derivation are not very clearly understood by those who use them.

Of the five Foreign Members whose names appear in the lists of the additions which the Royal Society has received during the last year, it is with deep regret that I observe those of two of them also in the record of its losses: the first is that of Professor Meckel of Halle, the second that of M. Desfontaines of Paris.

DR. JOHN FREDERICK MECKEL, Professor of Anatomy in the University of Halle, was the third member of a family singularly illustrious in the annals of physiological and anatomical science. His grandfather, at the beginning of the last century, was probably the greatest anatomist of his age, and was the founder of that collection which has become, by the additions of his son and of his grandson, the richest and the best arranged in Germany. His father was likewise an eminent anatomist, and greatly distinguished for his success in the practice of physic and of surgery, and for his general attainments. It was for the purpose of enriching the great collection which he inherited, and of completing those departments of it in which it was deficient, that young Meckel first directed his whole attention to comparative anatomy; but the results of his labours were not confined to his museum: he published a German translation of the *Anatomie Comparée* of Cuvier, which was enriched with many valu-

able notes. This was followed by his Contributions to Comparative Anatomy; by his *System der vergleichenden Anatomie*, which he did not live to complete; his *Tabulæ Anatomico-pathologicae*; his *Handbuch der pathologischen Anatomie*; his work On Human Monsters, and several memoirs relating to this branch of medical science, which display a remarkable union of laborious research with the most profound and original views relating to the phenomena of animal life. He devoted a great portion of his time to the publication of the *Archiv für Anatomie und Physiologie*, one of the most valuable and instructive periodical publications on medical and physiological science which appeared in Germany. One of his last works, on the Lymphatic System, which is upon a magnificent scale, was dedicated to the celebrated Sömmerring, upon the completion of his fiftieth year from the period of his inauguration as Doctor in Medicine, as a tribute of respect to one who had been his own preceptor, the fellow-student of his father, the follower and pupil of his grandfather, the intimate friend of his family for three generations, and who was also one of the few of his living rivals in the sciences which he cultivated.

Meckel was only fifty years old at the time of his death: he united in a very remarkable degree the power of correct and philosophical generalization with the most profound and accurate knowledge of anatomical details; and though he may have left in his own country some who may equal or even surpass him in particular departments of human and comparative anatomy or physiology, there is no one of his countrymen, if, perhaps, Tiedemann be excepted, who can be considered as having made such important additions to our general views in those sciences.

RENE' LOUCHE DESFONTAINES, Professor of Botany at the Jardin du Roi, and one of the most distinguished botanists in Europe, was born at Tremblay in 1752. In the course of the years 1782 and 1783 he travelled, for the purpose of forming botanical collections, to the North of Africa, penetrating as far as the range of Mount Atlas; and his *Flora Atlantica*, which was published in 1798, a splendid and richly decorated work, contains the principal results of his labours. It was in the same year that his celebrated memoir on the Organization of Monocotyledonous Plants was read to the Institute, in which he demonstrated the different manners in which the ligneous fibres are developed in plants with simple and double cotyledons, and thus laid the foundation of two great and fundamental divisions in the vegetable kingdom*. He was the author of the *Tableau de l'École de Botanique du Muséum d'Histoire Naturelle*, of the *Histoire des Arbres et Arbrisseaux qui peuvent être cultivés en pleine terre sur le Sol de la France*, of a *Manuel de Cristallographie*, according to the system of Romé de l'Isle, of many elaborate articles in the *Dictionnaire des Sciences Naturelles*, and other similar publications;

* Traces of this distinction in the structure of Monocotyledonous and Dicotyledonous plants may be found in the writings of Grew, Malpighi, and Daubenton, though its full developement was reserved for M. Desfontaines.

and of a great number of Memoirs, chiefly in the *Annales du Muséum d'Histoire Naturelle*, which were for the most part descriptive of new genera and species of plants cultivated in the *Jardin du Roi*, the management of which had devolved upon him conjointly with MM. de Jussieu and Thouin.

M. Desfontaines was a person of mild and inoffensive manners, and perfectly free from those feelings of jealousy which tend to provoke either opposition or controversy. For a considerable period before his death he laboured under the affliction of total blindness, and was thus debarred from the continuation of those pursuits which had constituted at once the delight and the business of his life: and it was a fortunate circumstance that a visitation of Providence, which under ordinary circumstances would have produced a spirit of repining and discontent, was deprived of more than half its bitterness and severity by the spirit of contentment and resignation with which it was met.

At the conclusion of my Address to you, Gentlemen, last year, I felt called upon, at once by my subject and my feelings, to pass from the notice of the *certain* losses which the Society had sustained during the preceding year, to one which circumstances at that time rendered too probable. The long absence of Captain Ross and his companions, the perilous enterprise upon which they were engaged, the fearful alternative of shipwreck or famine which seemed their almost inevitable fate, had left few elements for hope, except in those who steadily trust in the unlimited resources of Providence to accomplish its ends, however remote and wonderful. I rejoice at the unlooked-for accomplishment of that hope, and I know that you, Gentlemen, one and all, will equally participate with me in these feelings. Captain Ross and his brave companions were "lost, and are found;" and I trust that the enthusiastic welcome which has met them upon their return will convince them that the heart of their country is that of a parent.

I forbear, Gentlemen, to mix up other topics with the expression of those feelings to which this happy event naturally gives rise, and however important may be the contributions to geography or to science which these perilous and painful adventures may have produced, I consider them, in the present condition of my feelings, but as dust in the balance, when compared with the knowledge of the important fact of the recovery of our long lost brethren.

Permit me then, Gentlemen, in your name as well as in my own, to offer to Captain Ross, whom I rejoice to see amongst us, our most cordial congratulations upon his happy return, and to express our hope that the sympathy and respect of his countrymen which he has already experienced, and which, I trust, he will retain for the remainder of his days, will form one of the best compensations for the long sufferings which he has endured, and for the incomplete success of an enterprise presenting difficulties from the certain operation of the laws of the physical world, which not merely baffle, but almost annihilate, the powers of the bravest, the strongest, and the most persevering of men.

THE Secretary reported, on the part of the Council, that they had received an application from the Lords of the Treasury, for their opinion respecting the construction and mode of applying an instrument for ascertaining and charging the duty on spirits: in compliance with which they appointed a Committee to conduct the investigations required for that purpose. The Committee, after bestowing considerable labour and pains on this subject, agreed in a Report, which was adopted by the Council, and transmitted to the Lords of the Treasury, and for which they have received their thanks, for the labour and attention they have given to this subject. They have lately also received an intimation from the Treasury, that their further assistance will be requested to superintend, examine, and assist in the construction of the instruments and tables which will be required.

The Treasurer made the following statements with respect to the Number of Fellows, the State of the Finances, and the Receipts and Payments of the Society during the preceding year.

At the last Anniversary, the Society consisted of 748 Members ; of whom there were,

11 Royal Personages,
45 Foreign Members, and
692 Home Members.

Since that date, there have died,

20 on the Home List, and
4 on the Foreign List,

and there have been admitted,

17 on the Home List, with
1 re-admission, and
5 on the Foreign List. Of whom

8 have compounded for life, and
10 have engaged to pay the Annual Subscription of 4*l*.

The Society therefore now consists of,

11 Royal Personages,
46 Foreign Members, and
690 Home Members ;

making a total of 747 Members ; of whom

595 have compounded for life,
403 at the rate of 27*l*. 6*s*.
192 at the rate of 40*l*. 0*s*.

44 are subject to an annual payment of 2*l*. 12*s*.

51 are subject to an annual payment of 4*l*. 0*s*.

The DISBURSEMENTS of the Society may be classed under two heads:

1. Those which are *ordinary*; and
2. Those which are *extraordinary*, and not likely to recur.

The ordinary disbursements may be estimated in the following manner:

Salaries.....	£ 645
Lighting	80
Coals.....	40
Taxes	50
Charwoman and Servant.....	42
Postage.....	30
Fire Insurance	22
Miscellaneous	200
	<hr/>
	£ 1109

The annual expense of printing the Philosophical Transactions has been, on an average of the last five years, £894, (without including the charges for stitching and for advertisements,) viz.

For Printing	£ 350
For Paper.....	259
For Engraving	285
	<hr/>
	£ 894

These expenses attending their publication vary, of course, very much, according to the number of pages, the quantity of engravings, and the nature of the Papers, included in each volume.

Besides these ordinary disbursements, there is at present the expense of the Catalogue, which will probably cost the Society not less than £1000, including the expense of printing; and, for the present year, the cost of the Fluid-Lens Telescope (£157 10s.), and printing the Abstracts (£583 6s. 9d.), against the latter of which sum £141 18s. 6d. has been already received.

The INCOME of the Society is derived from

Rents	£ 284
Dividends on Stock.....	501
Quarterly and Weekly Contributions, about	270
Sale of Philosophical Transactions, about ..	350
	<hr/>
	£ 1405

also whatever may be received from the Admission Fees or Compositions of new Members, which is fluctuating. The Admissions have been, on an average of the last five years, twenty-six, which would give of course £260 per annum for Admission Fees of £10 each; and the average number of Members who have compounded for Annual Contributions, during the same period, being twenty-one, the amount of Compositions at £40 each would be £840,—making a mean total of £1100 per annum for Admission Fees and Compositions. But it being now optional for Members to compound or not for Annual Payments, the Compositions (of which there have been only seven during the past year,) will most probably go on consider-

ably decreasing in number, or cease altogether : and until the amount of the present annual subscription of £4 is come into full operation, a temporary inconvenience will be experienced from this circumstance, as well as from the falling off in the Compositions^a.

Besides these sources of Income, there are other sums invested in the Funds ; namely,

	£.	s.	d.	
The Fairchild Fund,	100	0	0	New South Sea Stock.
The Rumford Fund,	2161	0	10	Three per Cent. Consols.
The Donation Fund,	3820	19	3	Three per Cent. Consols.

of which the dividends are not applicable to the general expenses of the Society, but must be disposed of according to the intention of the respective donors.

The clear annual *Income*, therefore, which may for some time be expected,—without taking into consideration whatever may be received on account of the Admission Fees or Compositions of new Members,—may be considered as only £1400 : and the probable annual amount of *Ordinary Expenses* as £2000^b.

^a *Compositions and Purchases of Stock* (Minutes of Council, Dec. 5, 1833).

Compositions.—During the last twenty years, from November 30, 1813, to November 30, 1833, 463 Members have compounded for their Annual Contributions :—

	£.	s.	d.
257 at the original sum of £27 6s., making an amount of...	7016	2	0*
206 at the present sum of £40, making an amount of.....	8240	0	0

so that, during this period, £15,256* have been received on account of Compositions for life. Of this sum, only £3915 have, during the same period, been invested in the purchase of Stock.

There are at present 595 Members who have compounded for Annual Payments ; of whom 403 compounded at the rate of £27 6s., and 192 at that of £40.

Purchases of Stock (not including those on account of the Rumford or Donation Fund).—In 1813, the Funded Property of the Society, strictly so considered, was £11,361 13s. 4d. Stock, in the Three per Cent. Reduced Annuities. Since that date, (viz. during the last twenty years,) the following purchases have been made of the same kind of Stock :—

	£.	s.	d.		£.	s.	d.
In 1820 ...	2882	17	8	Stock, purchased for	2000	0	0
1821 ...	755	9	0		570	7	4
1829 ...				£1000 for £870 19s. 1d.,			
				of which one half was, a few months after,			
				sold again at £459 7s. 6d., leaving only,	411	11	7
				500 0 0 Stock, purchased for			
1830 ...	1000	0	0		933	15	0
Total	£5138	6	8		£3915	14	0

	£.	s.	d.
Stock, Nov. 30, 1813	11,361	13	4.
Do. purchased	£.	s.	d.
in 20 years...	5138	6	8
Deduct sale.....	2500	0	0

2638 6 8

Stock, Nov. 30, 1833 ... £14,000 0 0

^b The average amount of annual expenses for the last twenty years is £2330.

* Corrected.

*Statement of the Receipts and Payments of the Society between Nov. 30, 1832,
and Nov. 30, 1833.*

1. RECEIPTS.

	£.	s.	d.
Balance in the hands of the Treasurer at the last Audit....	536	16	1½
Weekly Contributions at one shilling.....	124	12	0
Quarterly Contributions at £1.....	158	15	6
Seventeen Admission Fees	170	0	0
Eight Compositions for Annual Payments	320	0	0

Rents :	£.	s.	d.
One year's rent of estate at Mablethorpe: due at Michaelmas	107	0	0
One year's rent of premises in Coleman- street: due at Michaelmas	95	0	0
One year's rent of lands at Acton: due at Michaelmas	60	0	0
One year's fee-farm rent of lands in Sus- sex; land-tax deducted: due at Mi- chaelmas.....	19	4	0
One-fifth of the clear rent of an estate at Lambeth Hill, from the Royal College of Physicians, in pursuance of Lady Sadleir's will: due at Midsummer ..	3	0	0
	<hr/>	284	4 0

Dividends on Stock :

One year's dividends on 16,500 <i>l.</i> Reduced Annuities	495	0	0
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Pulteney Fund.

One year's dividends on 200 <i>l.</i> 3 per cent. Consols	6	0	0
--	---	---	---

Fairchild Fund.

One year's dividends on 100 <i>l.</i> New South Sea Stock	3	0	0
--	---	---	---

Rumford Fund.

One year's dividends on 2161 <i>l.</i> 0 <i>s.</i> 10 <i>d.</i> 3 per cent. Consols	64	16	8
--	----	----	---

Donation Fund.

One year's dividends on 3820 <i>l.</i> 19 <i>s.</i> 3 <i>d.</i> 3 per cent. Consols	114	12	6
	<hr/>	683	9 2

Carried forward £2277 16 9½

	£.	s.	d.
Brought forward	2277	16	9½
Miscellaneous Receipts :			
	£.	s.	d.
Sale of Philosophical Transactions ...	362	6	0
Sale of Abstracts of Papers	141	18	6
Sale of Sir H. Davy's Discourses	4	13	0
		508	17 6
Sale of £2500 Stock, 3 per cent. Reduced Annuities	2174	17	6
Total	£4961	11	9½

2. PAYMENTS.

	£.	s.	d.
<i>Copley Medal</i> .—Mr. Wyon: The value and striking of Six Copley Medals	32	2	0
<i>Lady Sadleir's Legacy</i> .—The Poor of the Parish, in pursuance of Lady Sadleir's Will	3	0	0
<i>Bakerian Lecture</i> .—S. H. Christie, Esq., for the Bakerian Lecture of 1833	4	0	0
<i>Fairchild Lecture</i> .—The Rev. J. J. Ellis for delivering the Fairchild Lecture of 1833	3	0	0
<i>Rumford Medal</i> .—Professor J. F. Daniell: Two years' Dividends on the Rumford Augmentation Fund; Nov. 30, 1832.	67	9	6
————— Mr. Wyon: The value and striking of a Gold and Silver Rumford Medal	64	0	0
<i>Donation Fund</i> .—The Trustees of the Arctic Land Expedition: One year's Dividends	113	12	0
Salaries:			
	£.	s.	d.
Dr. Roget, one year, as Secretary	105	0	0
J. G. Children, Esq., one year, as Secretary	105	0	0
Ditto for Index to Phil. Trans.	5	5	0
C. König, Esq., one year, as Foreign Secretary	20	0	0
Mr. Hudson, one year, as Assistant-Secretary	250	0	0
Ditto, for Report on Medals and Lectures	21	0	0
Mr. Robertson, one year, as Assistant to ditto	100	0	0
Mr. Gould, one year, as Porter	60	0	0
		666	5 0
Mr. Panizzi: On account; for preparing a Catalogue of the Library	150	0	0
Mr. Robertson: For assisting Mr. Panizzi: One year	54	12	0
Mr. Dessiou: For superintending the printing of Observations of the Tides	5	0	0
Mrs. Coppard: Gratuity	10	0	0
Fire Insurance, on the Society's Property	22	11	6
Carried forward	£1195	12	0

£. s. d.
Brought forward 1195 12 0

Bills :—

Taylor :	£.	s.	d.
Printing the Phil. Trans., 1832, part 2 .	242	12	6
Printing the Phil. Trans., 1833, part 1 .	134	10	8
Printing and Paper for Abstracts of Papers in Phil. Trans., 1800–30, vol. i. and ii., in 4to and 8vo	583	6	9
Printing and Paper of Proceedings, Nos. 11 and 12, and reprints of Nos. 1 to 10	80	15	0
Printing of General Index to Phil. Trans. 1820–30	37	13	0
Printing and Paper of Observations of Tides	38	11	0
Miscellaneous Printing: Circulars, Lists of Fellows, Ballot-lists, State- ment of Payments, President's Ad- dresses, Minutes of Council, and for Advertisements	125	1	0
Bowles and Gardiner :			
Paper for the Phil. Trans., 1833, part 1 .	110	5	0
Paper for the Phil. Trans., 1833, part 2 .	227	10	0
Paper for General Index to Phil. Trans. 1820–30	45	10	0
Balance of former Account	5	5	0
Basire :			
Engraving and Copper-plate printing for the Phil. Trans., 1833, part 1 . .	30	14	4
Engraving and Copper-plate printing for the Phil. Trans. 1833, part 2 . .	233	6	0
Engraving and Copper-plate printing of Circulars, Diplomas, &c.	10	6	6
Walkers :			
Engraving and Copper-plate printing for the Phil. Trans. 1833, part 1 . .	70	18	6
Gyde :			
Sewing 1778 Parts of the Phil. Trans.	59	5	4
Boarding 22 Parts of ditto, gilt . . .	2	4	0
Sewing 790 Parts of ditto, Index 1820–30	13	3	4
Boarding 11 Parts of ditto	1	2	0
Boarding 300 Sets of Abstracts, 2 vols. 8vo	20	0	0
Boarding 200 ditto ditto, gilt . . .	23	6	8
Boarding 50 ditto ditto, 4to . . .	9	3	4
Boarding 50 ditto ditto, gilt . . .	12	10	0
Boarding 8 First and Second Indexes, gilt	1	0	0

Carried forward £2117 19 11 1195 12 0

	£.	s.	d.	£.	s.	d.
Bills :—						
Brought forward	2117	19	11	1195	12	0
Few & Co., Solicitors	10	1	6			
Tuckett :						
Bookbinding	24	14	0			
Limbird :						
Stationery and Stamps	58	7	3			
Saunderson :						
Shipping Expenses	25	11	5			
Dollond :						
A Fluid-lens Telescope	157	10	0			
Arranging, engraving, and repairing instruments	20	0	0			
Arnold and Johnson, Coal-merchants .	41	0	4			
Brecknell and Turner :						
Wax Lights, Candles, and Lamp Oil .	83	13	2			
Skelton :						
Cleaning Chandeliers; Candlesticks; Fire-guard; and repairing Lamps and Locks	23	14	6			
Pryer and Spice :						
Carpet-beating; Excise Box; Ladder; Plasterer's Work; Packing Cases .	31	15	0			
Carr : Carpenter	3	18	11½			
Caldecott :						
Two moveable Book Stands	5	13	0			
Cobbett and Son :						
Window-cleaning and Glazing	8	10	6			
Hornby & Co. :						
Soap, large Mats, Brushes, Fire-Wood .	27	4	4			
Illidge :						
China for Library Tea	2	8	0			
				2642	1	10½
Books bought on account of the Money received from the British Museum :—						
Baillière : Books,—on account	327	13	5			
Simpinkin and Marshall: Ditto	4	14	8			
Bohn : Ditto	3	4	0			
Maynard : Ditto	25	13	6			
Rich : Ditto	1	12	0			
Freight and Clearing	6	9	6			
				369	7	1
Parish Rates and Petty Charges :						
Taxes and Parish Rates	49	8	9			
L'Institut Journal: half a year	2	9	0			
Postage and Carriage	27	10	3½			
Extra Porterage and Delivery of 2250 Circulars	35	3	0½			
Men in Libraries, removing books, &c..	10	16	10			
Carried forward	£125	7	11	4207	0	11½

	£.	s.	d.	£.	s.	d.
Parish Rates and Petty Charges:						
Brought forward	125	7	11	4207	0	11½
Expenses on Foreign Packets and Presents	15	11	1			
Carriage of Cuvier's Bust	5	19	4			
Address to the King: engrossing and vellum	4	13	0			
Charwoman's Wages	12	12	0			
Board and Wages of Servant	30	0	0			
Miscellaneous expenses	16	18	4			
	<hr/>			211	1	8
				£ 4418	2	7½
Balance in the hands of the Treasurer				543	9	2
				<hr/>		
				£ 4961	11	9½
				<hr/>		

The Treasurer also reported, that no arrears of any kind remained unpaid, or due to the Society.

The Society next proceeded to the election of the Council and Officers for the ensuing year, when the following was declared to be the list :—

President : His Royal Highness the Duke of Sussex, K.G.—
Treasurer : John William Lubbock, Esq., M.A.—*Secretaries* : Peter Mark Roget, M.D.; John George Children, Esq.—*Foreign Secretary* : Charles Konig, Esq.

Other Members of the Council : Francis Baily, Esq.; Peter Barlow, Esq.; William Thomas Brande, Esq.; Benjamin Collins Brodie, Esq.; Mark Isambard Brunel, Esq.; William Clift, Esq.; Rev. James Cumming; Michael Faraday, Esq.; Davies Gilbert, Esq.; George Bellas Greenough, Esq.; Rev. Philip Jennings, D.D.; Rev. George Peacock; William Hasledine Pepys, Esq.; Rev. Baden Powell; Rev. Adam Sedgwick; Captain William Henry Smyth, R.N.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1833-1834.

No. 15.

December 5, 1833.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer,
in the Chair.

James Copland, M.D. ; Edwin Pearson, Esq., M.A. ; and Charles
Terry, Esq., were elected Fellows of the Society.

December 12, 1833.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

The Reports received by the Secretaries, from Sir John Herschel, Professor Airy, and Captain Smyth, on the Fluid-lens Telescope constructed for the Royal Society on Mr. Barlow's principles, were, by direction of His Royal Highness the President and Council, read to the Society at this meeting.

Sir John Herschel's Report.

I have seen Mr. Barlow's telescope at Cambridge, and examined it on several objects, in a very fine night, the 25th (if I remember) of June. As I have now no time to give it any further trial at Slough, (where I have no longer, either, any achromatic telescope of sufficient power to compare it with, all my apparatus being dismounted and in course of packing,) I will here state in few words, as *my* report on it, all I could then collect relative to its action.

1. *Achromaticity*.—Mr. Barlow's telescope is remarkably free from the dispersion of colour, very much more so than I could have expected from the nature of the correcting medium, and nearly or quite as much as could be desired.

2. *Light*.—The great aperture is very efficient under moderate powers on faint objects; and it concentrates the smaller stars well, and would, I have no doubt, show the larger nebulae, &c., and be well available as a *sweeping telescope*.

3. *Distinctness*.—Very good with powers under 100 or 150; but on the occasion on which I tried it, it seemed to break down under high powers, and there was evidently a considerable want of correction of spherical aberration. As I had no opportunity of trying it in different temperatures, I cannot say whether this want of correction might not disappear in a different temperature,—it was about 65° when I looked through it,—neither could I ascertain whether this

arose from the glasses not being at the right distances, there being no means, or the means not having been explained to me, by which the correcting lens could be got at, to shift it.

4. A very troublesome degree of colour out of the centre of the field.

This report is of course too meagre and imperfect to conclude much from, but as both Capt. Smyth and Prof. Airy have examined it in much detail, I the less regret that my present circumstances will not allow of my going further into the subject.

J. F. W. HERSCHEL.

July 23, 1833.

Professor Airy's Report.

From the pressure of business I have had fewer opportunities of trying the telescope than I could have desired. The absence of bright planets also has prevented me from attending so much as I wished to what I regard as the most important point in this construction, namely, the correction of colour. I have, however, had one excellent opportunity of observing the moon, and have observed several stars, single and double, and do not think that my opinion could have been altered by a greater number of observations. The correction of colour is not complete, but it is much more nearly complete than I expected, and very much more so than in a smaller telescope of Mr. Barlow's construction which I tried several years since. The colour is so far removed that it is not offensive till a power of 300 is used. But with regard to this colour, there is one point of great importance to be noticed by any person who shall try the telescope in future. It is that, in consequence of the separation of the object lenses, the only part of the field which can possibly be free from colour with a common eyepiece is in the line passing through the centres of the two object lenses; and that from the present imperfect centering, this line falls actually out of the field of the highest power (or quite on the edge). An eyepiece of a different construction and adjusted with greater care is necessary before any positive decision can be given. With regard to the definition of a star, it is not at present good, and the telescope is decidedly incompetent to separate any close star; but I regard this as a fault in the making of the surfaces, to which any telescope is liable, and which does not interfere at all in my estimation of the value of the new principle of construction. I know not how far a circumstance mentioned by Mr. Dollond (the alteration of spherical aberration with an alteration of temperature) may account for this; but so much of the irregularities are cut off by cutting off the external ring of the object glass, that I have no doubt of its being due principally to the figure.

My opinion is, therefore, that a larger telescope, as good of its kind as the present, would be very useful for nebulae, &c.; and that if freed from defects, which do not appear to belong to the construction, it might be equal to any astronomical work except the examination of bright planets.

I have had the advantage of trying the telescope once in company with Sir John Herschel, Sir David Brewster, Mr. Cooper, Dr. Ro-

binson, and Professor Hamilton, and their opinion upon the whole coincided nearly with mine.

I beg to suggest the propriety of attaching a finder to the telescope, as much time is lost in seeking for any object.

G. B. AIRY.

June 20, 1833.

Captain Smyth's Report.

I beg you will inform His Royal Highness the President, and the Council of the Royal Society, that I have this day packed up the fluid refracting telescope of which they have done me the honour of asking my opinion, and that it will be forwarded to Professor Airy without delay. It might indeed have been sent to Cambridge sooner, but that I waited for the first quarter of the present moon, to test the light and the performance of the instrument; but I regret that though I was constantly upon the spot, the weather has prevented my having an opportunity of catching her, till she was past her dichotomy, and consequently too glaring for the purpose.

On the arrival of the telescope, it was carefully unpacked, and immediately mounted, for the moment, on the lower slab of the revolving roof of my polar-axis room. It was fitted by its two pivots to the iron crutch which was sent with it, the upper parts of which were cut into Y's: the inner end was supported by Mr. Dollond's ingenious "eye-end stand." The instrument, however, was liable to tremor, both from the motion of the roof and the floor; but it enabled me to examine a few objects while poles were being prepared to form a better stage outside the observatory. And I should remark, that it was arranged with Professor Airy, who favoured me with a visit on the occasion, that my experiments were to be entirely confined to the performance of the telescope, while he would investigate its principle. My portion was to be governed by direct comparisons with my refractor, as a standard from which to assume the relative merits of the two. That instrument has a double object-glass of $5\frac{1}{8}$ ths inches clear aperture, and $8\frac{1}{2}$ feet focal length; a space which I have good reason to think is accurately proportioned to the densities of the crown and flint glasses: and notwithstanding the magnitude of the diameters, the curves of the lenses seem in tolerably exact chromatic and spherical aberration throughout. It may therefore be presumed to be a more severe reference than the dimensions alone would suggest.

The temporary stage alluded to, outside the observatory, consists of two upright beams of fir, firmly driven into the bed of gravel which forms the substratum of the garden, and a cross-bar, strongly screwed, supports the iron crutch with its Y's. This is erected close to a platform and pier, which were built for some magnetic experiments, and afforded great facility in attending to the outer lens, and augmenting or diminishing its aperture. While looking towards the south, it commanded from nearly a horizontal view to above 60° of elevation; and by unshipping it, and turning it northwards, it swept the polar region. Such being the means, it remains faithfully to report what I observed, regretting, at the same time, that the weather has continued mostly unfavourable.

Monday, Feb. 25, 1833.—The evening cleared off, and was very fine from 8 till nearly 11 o'clock P.M. At 7, I placed the instrument on its stand; at 9, the thermometer was $37^{\circ}6$, the barometer 29.32, and the hygrometer .771; and the wind was at S.E.

1. *The Moon.*—The examination of the lunar cavities and shadows was rather unsatisfactory. Under the powers 250 and 400, it bore the whole aperture; but with 90 and 150, there were two spectra, one of which haunted the centre. In definition, the fluid was excelled by the flint-glass, both instruments being very steady.

2. *The great Nebula in Orion.*—This mass was seen very fairly with the whole aperture; and the trapezium was beautifully distinct under all the powers except that of 400. From the examination of this object, the best performance seems to be with the eyepieces 150 and 250. The relative light of the flint-glass and the fluid-refractors, when the latter was reduced to six inches of aperture, appeared very nearly equalized.

3. *Venus.*—This trial was altogether unsatisfactory, from the strong irradiation and the quantity of loose light. The planet was, however, low down in the west, in a stratum of mist. The only power used was the one of 90 times; but there was a great defect in distinctness.

4. *Rigel.*—This star was in the S.W., and rather low; it was therefore, as might have been expected, surrounded with teasing rays, through which I had some difficulty in detecting the small companion. The star had a spurious but broken disc, and was full of colours in every part of the field except the centre, where they were partially destroyed. Powers 150 and 250.

Tuesday, Feb. 26, 1833.—At 9 in the morning, with the thermometer at $38^{\circ}8$, and the hygrometer .798, I examined an enamelled watch-face, which is firmly fixed upon a distant chimney of solid construction; and though the solar focus could not be used, I considered sufficiently distinct vision would be obtained to test the achromaticity of the telescope. The plate itself bore the trial better than did the edges of the chimney-sides, where the focus could not be adjusted so as to prevent the alternate production of light green and purple mist, as the eye-tube was pushed in or out: and these colours scarcely disappeared, even when brought into the centre of the field of view. Some of this might probably be corrected by adjusting the fluid-lens for near objects: and Professor Barlow writes to me, that this can readily be done; but that he took off the screw-head, by which it is effected, to prevent mere lookers-on from deranging the instrument. The watch-face being upon a dark ground, I played the eye-tube till I procured a spurious disc over it, by which I was satisfied that the centering was very nearly accurate.

I then left the telescope *in statu quo*, and at half-past 12 again inspected it, the thermometer being $47^{\circ}6$, the barometer 29.23, the hygrometer .789, and the wind S.S.W.; particulars which I carefully noted, for a reason which will presently appear. The watch-plate was now considerably plainer, and its figures more sharp and distinct; but the focus required shortening in; and though there was less colour than before, I was surprised to find it verging to the prismatic extreme, and tinged with red; a circumstance which ocular foci, or the distance,

would hardly account for. I repeated the examination in the evening, when the thermometer was $45^{\circ}4$, and the hygrometer $\cdot 790$. I now found that the focus required lengthening; but the vision was at its best, and the colours had almost vanished, though a foggy spectrum was perceptible at times. High powers, of course, did not agree with so near an object; but they were used without greatly distorting the image.

Thursday, Feb. 28, 1833.—The weather was very fine from 10 to 12 P.M., though the wind blew occasionally in hard squalls from the S.W. The instrument appeared but little affected, and yet the observations were rendered unsatisfactory by the frequency of these gusts. At 11 the thermometer was $38^{\circ}4$, the barometer $29\cdot 45$, and the hygrometer $\cdot 723$.

1. *σ Orionis.*—Saw 8 of the 10 stars which compose this cluster, but not sharp. The situation was unfavourable, it being two hours and a half off the meridian, and the S.W. quarter of the heavens was hazy. The power used was 250.

2. *ζ Orionis.*—This, of course, was very plainly seen; but I fished it up for its definition. The large star had a formidable nimbus, yet it did not prevent the increase of dark vacancy on raising the magnifying powers. There was much less loose light than I expected, and the small star was palpably of a pale-blue tint.

3. *Rigel.*—This star was now too far in the S.W. to be made much of: it was tremulous, and greatly irradiated under power 250. The companion was not visible, and there were two troublesome spectra.

4. *Saturn.*—The body of the planet bore magnifying powers, and showed the thin silver line of ring which now appears, without distortion, but certainly without sharp definition. I could only perceive two of the satellites, while with the flint-glass refractor I saw three. The whole aperture was too much for the instrument, and it was therefore cut off to six inches.

5. As the north was now the clearest part of the heavens, at about 11 o'clock the telescope was turned to that direction. The pole-star and its companion were seen very distinctly, even under the lowest power. This, of course, I expected; but I found that it was also viewed on both sides of the object-glass, with much less colour than the other tests I had been looking at.

Monday, March 4, 1833.—This was the best night I had yet had, and it continued very fair till nearly midnight. I was somewhat troubled with dew, but the instrument was free from tremors, and worked as well as its temporary mounting could admit of. The temperature stood thus:

	8 o'clock.	10 o'clock.	Midnight.
Thermometer	$45^{\circ}5$	$43^{\circ}6$	$40^{\circ}5$
Barometer	$29\cdot 85$	$29\cdot 86$	$29\cdot 89$
Hygrometer	$\cdot 740$	$\cdot 737$	$\cdot 728$

1. *Rigel.*—This star was greatly discoloured at the edges of the field, and was accompanied by a singular spectrum, which was not destroyed by being brought into the centre. I caught the companion

by glimpses, but it was immersed among strong rays. The powers used were 90 and 250.

2. *Sirius*.—This brilliant star was still more discoloured than Rigel on either edge of the field of view, and had a continuous production of rays, which in the centre surrounded the star, but at the sides preceded and followed it, like the wings seen where a flint-glass is not homogeneous, but fainter. These irradiations, as well as the dispersed light, were considerably cut off by diminishing the aperture of the outer lens. The powers used were 90 and 150; and I tried with 400 to raise a disc, but it was altogether too much for the object.

3. σ *Orionis*.—Saw the whole of the 10 stars of this group, but with great difficulty, and, if the term may be used, under a dim definition. Indeed, had I not practically known the object, I am doubtful whether I could have made out the middle stars. It should, however, be also stated, that it was nearly three hours to the west of the meridian.

4. *The great Nebula in Orion*.—I placed the whole aperture upon this object; and though the moon was nearly at full, I easily made out its outline, as well as that of its companion. But the trapezium of stars, under high powers, was more distinct with an aperture of 6 inches than when the whole was applied. I could make out only four stars in this spot; it will be recollected, however, it was now three hours past the meridian, for the time of its transit will not allow of earlier experiment. This I regret, because so fine a constellation, from its composition and place, offers in itself a *thesaurus* of astronomical tests.

5. γ *Leonis*.—This beautiful double star was remarkably well seen, being nearly on the meridian. There was, however, much false light, but it did not hinder the colours being seen: the large star was slightly red, and the small one a Saxon green. The powers used were 90, 150, and 250.

6. ω^3 *Leonis*.—This was a test which, in the deficient arrangement of the apparatus, I could not manage; but notwithstanding there was much dispersed light, I should pronounce that with power 400 I saw the star elongated, and different from the other two *omegas*.

7. *The Præsepe*.—An examination of this cluster was very favourable to the defining power of the telescope, and its general distribution of light. I tried it under the eyepieces 90, 150, and 250.

8. ζ *Cancri*.—With some difficulty I made out this object to be triple, under a power of 250: that of 400 broke the rings of the spurious discs with disagreeable rays, so as to confuse the whole vision.

9. *Saturn*.—The planet was about two hours and a half to the east of the meridian when I placed the telescope upon it. It was tolerably defined, but with *muddy* edges, though it bore magnifying pretty fairly. I saw two satellites steadily, and a third by glimpses; and this was all I could do with my own telescope at the time of transit. The ring resembled a thin silvery bar lying equatorially across the planetary disc, and was sharper than the body of Saturn.

Wednesday, March 20, 1833.—I had now intended to wait for the first quarter of the new moon; but the night proved so fine and dark, that I re-examined some of the former tests, and observed some new

ones. There was a light N.W. wind, and the temperature was thus:

	9 o'clock.	Midnight.
Thermometer	37°·7	34°·4
Barometer	30·01	30·00
Hygrometer	·680	·670

1. *The great Nebula in Orion.*—This was now three hours and a quarter over the meridian, and yet it was seen in great beauty and distinctness under the whole aperture, with eyepieces 90 and 150. The trapezium was examined very closely with 250 and 400, which last it bore better than it had yet done; but only four stars were visible.

2. *σ Orionis.*—All the stars of this group were perceptible under the power 250, but they had the appearance of being seen in a second-rate reflector; so that I know not how a micrometer would work upon this instrument.

3. *Venus.*—The crescent which this planet now forms was better seen than heretofore, but an unseemly quantity of light still attended it; and under the higher powers the colours were intolerable. When, however, the focus of power 90 was nicely adjusted, and the planet brought exactly into the centre of the field, it was a beautiful object, despite of a secondary spectrum. The aperture was reduced, and I did not find, either now or on other occasions, that this sensibly affected the ocular focus.

4. *γ Leonis.*—This brilliant object was distinctly seen, and the dark vacancy between the stars increased more than did the spurious discs, while the magnifying powers were being raised, though much loose light and irradiations were thereby produced. And it is singular that the separation was improved by my placing a central disc of card-paper, two inches in diameter, on the outer lens.

5. *Messier's 46th Nebula.*—This was very fairly resolved into stars, and better with the whole than the reduced aperture. Eyepiece 90 showed it easily, but the higher powers gave it a very *turbid* appearance. The preceding cluster was brilliant.

6. *α Leonis.*—This star had a bunch of disagreeable rays shooting from it; and the light, when under the best adjustment I could give the focus, was curiously thrown to the northward. I was able, however, to raise a tolerable disc, and the small star at a little distance from Regulus was unusually distinct.

7. *24 Comæ Beren.*—I pointed to this remarkably pretty object to test the colours, and very readily perceived the large star to be of a bright orange colour, and the small a sea-green. This was one of the best sights I had yet had, and on the whole was satisfactory.

8. *ι Leonis.*—This, though a very close and unequal double star, was well shown, yet at times the stray light would obscure the companion. The large star was fairly figured, and the small seemed about the 10th magnitude, and of a greenish hue. It formed a fine test.

9. *Saturn.*—I had a good trial of this planet; and though the powers 90, 150 and 250 were borne, the disc was certainly not well

defined. The ring is still a mere *bar* lying across the equator : it was very well shown, as were also three satellites. When I applied the power 400, the whole field was strewn with harsh light.

10. γ *Virginis*.—This interesting star, though now so exceedingly close, was made double with 250, and very well shown ; but with 400 there was great tremor and irradiation, so that the discs were often confused into one.

Saturday, March 30, 1833.—After a continuance of bad weather for several days, it cleared off a little ; but in the mean time I had missed the favourable phase of the moon, for which I had been waiting. I therefore closed my examinations with the following one :

The Sun.—From the extreme volatility of the sulphuret of carbon, I was fearful of its expansion, and therefore had not yet turned the telescope upon the sun, lest the condensation of the solar rays, at the place where they traverse the fluid, should prove too much for the lenses. But on mentioning this apprehension to Professor Barlow, that gentleman assured me that an exposure of from five to ten minutes could do no mischief. I therefore this day reduced the aperture to three inches, and directed the instrument to the solar disc, when, sweeping over the luminary for about three minutes, I found the surface was quite clear of spots. On turning from it, I drew out the eye-tube, and looking at the fluid, perceived that the bubble was considerably diminished, but not so much as I had expected. This was the only time that I exposed the telescope to great heat.

These are the only experiments I have been able to make ; and the season of the year, together with the inefficiency of the apparatus, have certainly prevented me from assigning exact limits to the performance of this telescope. Still, as I had immediate reference to one of the best refractors extant, I may add the following conclusions, premising, that I have not constantly noted down the performance of the latter upon each test, because my end was to pronounce upon the fluid object-glass. I should also observe, that the magnifying powers of both the instruments were equally matched, and their apertures were generally proportioned to nearly six inches : the eyepieces were thus :

Fluid refractor	90	150	250	400
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Flint-glass ditto	93	157	240	416
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From the result of my observations, it has struck me that this ingenious principle has strong claims to consideration for its valuable optical powers, but that, in the present stage, it is more adapted for stars than for planets ; and should the application of it be tried on a larger scale, it might be made with sufficient illumination to examine the high-class nebulae ; a branch of practical astronomy which is now nearly shut against refractors. The defining power does not strike me as being so good as the light, nor does the achromatism seem to be perfect. Yet I should mention the want of focal and mechanical arrangement ; that the only adjustment I had for distinct vision was by the hand, with the sliding eyepiece tube ; and that slight derangements might be occasioned by the mounting and dismounting of the great tube, however carefully it was attended to.

I cannot but suspect that the performance of this telescope is affected by temperature, and that severe tests in the summer months might afford different conclusions to those which I have arrived at; but as I considered my opinion was desired on the instrument in its present state, I took no means for applying artificial heat. And, perhaps, the secondary spectrum which haunts the field might be mitigated, and the prismatic colours destroyed, by an alteration of the distance between the fluid and outer lenses; but the same consideration prevented my applying for a screw, by which it might have been effected.

But there is one condition of the instrument which, if correct, would be of greater importance than the rest, as connected with this Report. It strikes me forcibly, from the several effects I observed, that the focus has been cut too short; a defect which would seriously affect the spherical aberration of the outer or object lens and its dispersion: and this would account for the fluid refractor not performing better than the flint-glass one, without impugning the corrective powers of the sulphuret of carbon, or its skilful application by the scientific Professor.

April 4, 1833.

W. H. SMYTH.

A paper was then read, entitled, "An Account of some Experiments made in the West Indies and North America, to determine the relative Magnetic Forces, in the years 1831, 32, and 33." By the Rev. George Fisher, M.A., F.R.S.

The experiments of which the results are given in this paper were made by Mr. James Napier, late Master of H. M. S. Winchester. The needles were precisely similar to those used in the experiments described by the author in a former paper; and the observations were made with great care, and repeated several times at the same places; by which it appeared that the intensities of the needles continued unchanged during the whole period of the experiments; and the mean of all those made at one place was taken as the result. From these the relative forces at different places were computed, and stated in the form of a table.

A paper was also read, entitled, "On the Theory of the Moon." By John William Lubbock, Esq., V.P. and Treas. R.S.

M. Poisson, in a memoir which he has lately published on the Theory of the Moon, expresses the three coordinates of her path, namely, her true longitude, her distances, and her true latitude, in terms of the time. The author observes that the reasons for so doing adduced by M. Poisson, are the same as those which led Mr. Lubbock also to deviate from the course which had previously been always pursued by mathematicians, and to employ equations in which the true longitude is the independent variable. Instead, however, of integrating the equations of motion by the method of indeterminate coefficients, as the author had proposed, M. Poisson recommends the adoption of the method of the variation of the elliptic constants. In the present paper, Mr. Lubbock states the reasons which have determined him not to employ the latter method, founded chiefly on the advantages of obtaining complete uniformity in the methods used in the theories

of the moon and of the planets, and also in that of a greater rapidity of approximation by the improvements introduced in these methods.

Laplace, in the *Mécanique Céleste*, alludes to an equation of long period, of which the argument is twice the longitude of the moon's node, plus the longitude of her perigee, minus three times the longitude of the sun's perigee; and M. Poisson has shown that the coefficient of the corresponding argument in the development of the disturbing function equals zero: but the author shows that the same result may be arrived at very simply, by means of the method of developing the variation of the disturbing function.

December 19, 1833.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

A paper was read, entitled, "On the Position of the North Magnetic Pole." By Commander James Clark Ross, R.N., F.R.S.

The author remarks that the discordances in former observations made with a view to determine the position of the magnetic pole, have arisen partly from the irregularity of distribution in the earth of the substances which exert magnetic power, and partly from the great distances from the magnetic poles at which these observations have been made. The latter cause of uncertainty has been now, in a great measure, removed, by the numerous and accurate observations made during the late arctic expeditions. The object of the present paper is to put on record those which were made in the last voyage of Captain Ross, in which a spot was reached corresponding to the true north magnetic pole on the surface of the earth. The nature of the instruments, and the difficulties encountered in their practical employment, under the circumstances of the expedition, are fully stated. Having arrived, on the 1st of June, at north latitude $70^{\circ} 5' 17''$, and west longitude $96^{\circ} 45' 48''$, the horizontal magnetic needle exhibited no determinate directive tendency, and the dipping needle was within a minute of the vertical position, a quantity which may be supposed to come within the limits of the errors of observation; hence the author concludes that this spot may be considered as the true magnetic pole, or as a very near approximation to it, as far, at least, as could be ascertained with the limited means of determination of which he was then in possession.

A table of the observations, including those on the intensity of the magnetic force at various stations, is subjoined.

A paper was also read, entitled, "On the Quantity and Quality of the Gases disengaged from the Thermal Spring which supplies the King's Bath, in the City of Bath." By Charles G. B. Daubeny, M.D., F.R.S., Professor of Chemistry in the University of Oxford.

The author, pursuant to an intention expressed in a former paper read to the Society, undertook a series of experiments, for the purpose of measuring the gas evolved from the thermal springs at Bath during

a period of time sufficiently long to enable him to determine with tolerable precision its average amount, and to ascertain whether any great diurnal variations in its quantity can be detected. He also kept during the same period a corresponding register of the conditions of the atmosphere, as to temperature, humidity and pressure, in order to learn whether any connexion could be traced between these conditions and the quantities of gas evolved. The supplies, both of water and of gas, from the Hot Bath and the Cross Bath being insignificant compared with those from the King's Bath, the author confined his inquiries to the last of these, and chiefly to the gas arising from the apertures within its central area, which is about twenty feet in diameter; the other apertures without this circle from which gas issued being carefully stopped up. The gas was collected by a funnel-shaped apparatus, constructed of several sheets of iron riveted together, and the seams rendered airtight by white lead, supported on a frame, with contrivances for raising and lowering it as occasion might require. The observations were made during periods of from five to fifteen minutes, and continued daily from the 17th of September to the 18th of October inclusive. The average quantity of gas evolved per minute, as deduced from the mean of all the observations, is 267 cubic inches, giving a total daily volume of 223 cubic feet.

The author, by referring to the accounts on record of other thermal waters, concludes that the evolution of gas is a phenomenon as intimately connected with the constitution of these waters, as the presence of a definite quantity of certain saline ingredients, or the possession of a particular temperature; both of which probably continue unaltered for periods of indefinite duration, compared with the records of any human history. He considers this phenomenon to be explicable, by supposing that a large volume of these gases is pent up in some cavern of rock, at a great depth below the surface of the earth, which, at some former period, had been heated by volcanic action, and which, by the gradual cooling and consequent contraction of its external portions, exerts a continued pressure on the gaseous contents of its cavity, and determines the uniform flow of a stream of gas through crevices towards the surface.

It appears from the observations of the author that the quantities of gas disengaged, in a given time, from the King's Bath are somewhat variable; for the differences between the results obtained on successive days are too considerable to be ascribed either to errors of manipulation or to variations in the amount of gas escaping by other avenues. These fluctuations in quantity cannot be traced to have any connexion with those of the atmospheric pressure. Variations likewise were observed in the proportional quantities of carbonic acid contained in the gas evolved at different times, which latter variations the author thinks may perhaps be dependent on the former.

The author remarks, in conclusion, that the immensity of the volume of nitrogen gas which is disengaged from these thermal springs, and the entire absence of carburetted, sulphuretted and phosphuretted hydrogen, seems to afford additional presumption against the truth of the opinion that the nitrogen gas which escapes from volcanoes

and from these springs is derived from atmospheric air, held in solution by the water, and deprived of the greater part of its oxygen by animal and vegetable putrefaction. He is disposed to ascribe the deficiency of oxygen to some process of combustion, during which it unites with some base, forming a compound not easily volatilized by heat; and to account for the presence of carbonic acid, by the calcination of earthy carbonates, rather than by the combustion of coal or bitumen.

The Society then adjourned over the Christmas Vacation, to meet again on the 9th of January.

January 9, 1834.

BENJAMIN COLLINS BRODIE, Esq., Vice-President, in the Chair.

The Earl of Tyrconnel was elected a Fellow of the Society.

A paper was read, entitled, "On the empirical Laws of the Tides in the Port of London, with some Reflections on the Theory." By the Rev. William Whewell, M.A., F.R.S., Fellow and Tutor of Trinity College, Cambridge.

The present state of our knowledge of the tides is represented by the author as extremely imperfect, and at variance with the scientific character which Physical Astronomy is supposed to have attained; for although it be the universally received opinion that they are the direct results of the law of gravitation, the exact laws by which the phenomena are actually regulated with regard to time and place have never been strictly deduced from this general principle. The tide tables that have been given to the world are calculated by empirical methods, which are frequently kept secret by those who employ them; and the mathematical solutions of the problem hitherto attempted have been confessedly founded on hypotheses which are in reality very remote from the real facts; and accordingly it is doubtful whether they give even an approximation to the true result. The comparison of the results of theory with extensive series of observations had not been attempted previously to Mr. Lubbock's discussion of the tides of the port of London, recorded in the *Philosophical Transactions* for 1831. The establishment, on theoretical grounds, of rules for the calculation of tide tables, has been attempted by Bernoulli and by Laplace: the methods recommended by the former are probably the foundation of those at present used by the calculators of such tables, that of Laplace being complicated, and too laborious for practice. Original tide tables are very few; none, with which the author is acquainted, deserving that title, except those which are published for Liverpool, and those for London. The former, which are calculated according to rules obtained from Mr. Holden, from the examination of five years of observations, made at the Liverpool docks by Mr. Hutchinson, at that time harbour-master, are remarkably

correct. Several tide tables for London are annually published; but they vary considerably from one another. The method generally practised in England for the construction of tide tables for other places, has been to add or subtract some constant quantity, according to the place, assuming as a basis the tide tables either of London or of Liverpool; but this assumption of a constant difference is shown by the author to be, in various instances, incorrect. Much, therefore, remains to be done, before we can hope to arrive at a scientific solution of this problem.

The author then proceeds to examine the empirical laws of the tides of the port of London, deducible from the records of the nineteen years of observations which have been discussed by Mr. Dessiou, under the direction of Mr. Lubbock, and which include 13,073 observations. His first object is to determine the manner in which the time of high-water is affected by the following conditions, namely, the right ascensions, declinations and parallaxes of the sun and moon; for which purpose he considers at some length, first, the establishment; secondly, the semimenstrual inequality; thirdly, the corrections for lunar parallax; fourthly, the lunar declination; and lastly, the solar parallax and declination. He next discusses the empirical laws of the height of high-water; which he observes will be affected in the same manner as the periods of the tides, by a semimenstrual inequality, by corrections for lunar parallax and declination, and by a solar correction; and concludes by giving a formula for computation which comprehends all these elements. He then enters into a comparison of the results thus obtained with the theory of Daniel Bernoulli, according to which the waters of the ocean assume nearly the form in which they would be in equilibrium under the actions of the sun and moon, on the supposition that the pole of the fluid spheroid follows the pole of the spheroid of equilibrium at a certain angular distance; and that the equilibrium corresponds to the configuration of the sun and moon, not at the moment of the tide, but at a previous moment, at which the right ascension of the moon was less by a constant quantity. The author thinks, however, that it would not be safe to attempt to deduce from the preceding investigations any general views concerning the laws of the tides, for it is not likely that the discussion of observations at any one place should exhibit clearly the true principles of the theory, especially as, in the present case, it so happens that the phenomena of the tides at London are in some measure masked by a curious combination of circumstances, namely, by the mouth of its river being on the side of an island, turned away from that on which the tide comes, and so situated that the path of the tide round one end of the island is just twelve hours longer than round the other.

In consequence of the time required to transmit to any port the general effect of the tide-producing forces being different from the time required to transmit to the same port the effects of particular changes in these forces; or, in other words, from the epochs of the changes due to parallax and declination being different from the epoch of the semimenstrual inequality, it follows that although the general

form of the terms, and the variable part of the arcs on which they depend, may be deduced from the theory of equilibrium, yet the constant epoch which occurs in each of these arcs, and which determines when the inequality vanishes, and reaches its maximum, will probably have to be determined, in all cases, by observation.

In conclusion, the author gives a statement of what appears to him to be the most important steps from which any great improvement to our knowledge on the subject of the tides may be hoped; and recommends the discussion of extensive collections of observations made at a variety of places, in a manner similar to what has been done by Mr. Dessiou with regard to those at London; and the comparison with one another of the empirical laws resulting from their separate investigation. Very valuable materials for this purpose, he expects, will hereafter be furnished by the observations now making, on a judicious system, at the St. Katharine's docks.

January 16, 1834.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer,
in the Chair.

A paper was read, entitled, "On a new property of the Arcs of the Equilateral Hyperbola." By Henry Fox Talbot, Esq., M.P., F.R.S.

By an analytical process, the author arrives at the following theorem, namely, if three abscissæ of an equilateral hyperbola be materially dependent by reason of two assumed equations, which are symmetrical with respect to these three abscissæ, the sum of the arcs subtended by them is equal to three quarters of the product of the same abscissæ, or only differs therefrom by a constant quantity. In order to satisfy himself of the correctness of this theorem, the author calculated various numerical examples, which entirely confirmed it. This simple result is essentially a relation between three arcs of the equilateral hyperbola, and is by no means reducible to a relation between two; and therefore is not reducible to the celebrated theorem of Fagnani, concerning the difference of two arcs of an ellipse or hyperbola, nor to any other known property of the curve.

The reading of Mr. Faraday's Sixth Series of Experimental Researches in Electricity was commenced.

January 23, 1834.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

A paper was read, entitled, "Appendix to a Memoir, lately read to the Society, on the Quality and Quantity of the Gases disengaged from the Hot Spring of the King's Bath, in the City of Bath." By Charles G. B. Daubeny, M.D., F.R.S.

The author has lately examined two tepid springs, which, since the setting in of the wet weather, have broken out at the foot of St.

Vincent's rocks, Clifton, immediately below the Cliff, against which the suspension bridge over the Avon is designed to abut. The temperatures of the springs were 72° and 66° respectively; and the gas consisted of 92 parts of nitrogen, eight of oxygen, and three of carbonic acid. The author deduces from these facts arguments in confirmation of the views he has stated in the paper to which this is an appendix.

Mr. Faraday's Sixth Series of Experimental Researches in Electricity were resumed and concluded; and the reading of the Seventh Series commenced.

The Society then adjourned over the following Thursday, being the Day of the Martyrdom of King Charles the First, to meet again on the 6th of February.

February 6, 1834.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer, in the Chair.

Captain Chesney, Roy. Art.; Thomas Copeland, Esq.; the Right Hon. Sir Edward Cust, K.C.B.; James Horne, Esq.; John Russell Reeves, Esq.; Lieut.-Col. William Henry Sykes, E.I.C.S.; and John Waterhouse, Esq., were elected Fellows of the Society.

The reading of Mr. Faraday's Seventh Series of Experimental Researches in Electricity was resumed in continuation.

February 13, 1833.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G., President, in the Chair.

The reading of Mr. Faraday's papers was resumed and concluded.

"Experimental Researches in Electricity.—Sixth and Seventh Series." By Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain.

In the course of his experimental investigation of a general and important law of electro-chemical action, which required the accurate measurement of the gases evolved during the decomposition of water and other substances, the author was led to the detection of a curious effect, which had never been previously noticed, and of which the knowledge, had he before possessed it, would have prevented many of the errors and inconsistencies occurring in the conclusions he at first deduced from his earlier experiments. The phenomenon observed was the gradual recombination of elements which had been previously separated from each other by voltaic action. This happened when, after water had been decomposed by voltaic electricity, the mixed gases resulting from such decomposition were left in con-

tact with the platina wires or plates, which had acted as poles; for under these circumstances they gradually diminished in volume, water was reproduced, and at last the whole of the gases disappeared. On inquiring into the cause of this reunion of the elements of water, the author found that it was occasioned principally by the action of the piece of platina, which had served for the positive pole; and also that the same piece of platina would produce a similar effect on a mixture of oxygen and hydrogen gases obtained by other and more ordinary kinds of chemical action. By closer examination, it was ascertained that the platina, which had been the negative pole, could produce the same effect. Finally, it was found that the only condition requisite for rendering the pieces of platina effective in this recombination of oxygen and hydrogen is their being perfectly clean, and that ordinary mechanical processes of cleaning are quite sufficient for bringing them into that condition, without the use of the battery. Plates of platina, cleaned by means of a cork, with a little emery and water, or dilute sulphuric acid, were rendered very active; but they acquired the greatest power when first heated in a strong solution of caustic alkali, then dipped in water to wash off the alkali, next dipped in hot strong oil of vitriol, and finally left for ten or fifteen minutes in distilled water. Plates thus prepared, placed in tubes containing mixtures of oxygen and hydrogen gases, determined the gradual combination of their elements: the effect was at first slow, but became by degrees more rapid; and heat was evolved to such a degree, indeed, as frequently to give rise to ignition and explosion.

The author regards this phenomenon as of the same kind as that discovered by Davy in the glowing platina; that observed by Döbereiner in spongy platina, acting on a jet of hydrogen gas in atmospheric air; and those so well experimented on by MM. Dulong and Thenard. In discussing the theory of these remarkable effects, the author advances some new views of the conditions of elasticity at the exterior of a mass of gaseous matter confined by solid surfaces. The elasticity of gases he considers as being dependent on the mutual action of the particles, especially of those which are contiguous to each other; but this reciprocity of condition is wanting on the sides of the exterior particles which are next to the solid substance. Then, reasoning on the principle established by Dalton, that the particles of different gases are indifferent to one another, so that those of one gas may come within almost any distance of those of another gas, whatever may be the respective degrees of tension in each gas among the particles of its own kind, he concludes that the particles of a gas, or of a mixture of gases, which are next to the platina, or other solid body not of their own chemical nature, touch that surface by a contact as close as that by which the particles of a solid or liquid body touch each other. This proximity, together with the absence of any mutual relation of the gaseous particles to particles of their own kind, combined also with the direct attractive force exerted by the platina, or other solid body, on the particles of the gases, is sufficient, in the opinion of the author, to supply what is wanting in order to render effective the affinity between the particles of oxygen and hydrogen; being, in

fact, equivalent to an increase of temperature, to solution; or to any of the other circumstances which are known to be capable of adding to the force of the affinities inherent in the substances themselves.

Some very curious cases of interference with this action of platina and other metals are next described. Thus, small quantities of carbonic oxide, or olefiant gas, mixed with the oxygen and hydrogen gases, totally prevent the effect in question; while very large quantities of carbonic acid, or nitrous oxide gas, do not prevent it: and it is remarkable, that the former of these gases do not affect the metallic plates permanently; for if the plates be removed from those mixtures, and put into pure oxygen and hydrogen gases, the combination of these elements takes place.

The author concludes by some general notice of numerous cases of physical action, which show the influence of certain modifications of the conditions of elasticity at the external surface of gaseous bodies.

The seventh series, which is a continuation of the subject of the fifth, namely, electro-chemical decomposition, commences with a preliminary exposition of the reasons which have induced the author to introduce into this department of science several new terms, which appear to be required in order to avoid errors and inaccuracies in the statement both of facts and theories. As a substitute for the term *pole*, and with a view to express also a part of the voltaic apparatus to which that name has never been applied, although it be identical with a pole in its relation to the current, the author proposes to employ the term *electrode*. The surfaces of the decomposing body, at which the positive current of electricity enters and passes out, are denominated respectively the *eisode* and the *exode*. Bodies which are decomposable by the electric current are called *electrolytes*, and when *electro-chemically decomposed*, they are said to be *electrolyzed*; the substances themselves, which are evolved in such cases, being called *zetodes*, and the terms *zeteisode* and *zetexode* being applied, accordingly as the substance passes in one direction or the other. The propriety and the advantage of employing these new terms, the author observes, can be properly appreciated only by an experience of their uses and applications in the exposition of the theory of decomposition given in the fifth series of these inquiries, and of that of definite electro-chemical action advanced and supported in the present paper.

The first section of this paper is occupied with the consideration of some general conditions of electro-chemical decomposition. It has been remarked, that the elements which are strongly opposed to each other in their chemical affinities are those most readily separated by the voltaic pile; and the discovery of the law of conduction, explained in the fourth series, has led to a great augmentation of the number of instances which are in conformity with this general observation: but it is here shown, that the proportion in which the elements of a body combine has great influence on the electro-chemical character of the resulting substance; and that numerous instances occur where, although one particular compound of two substances is decomposable, another is not. It appears, that whenever binary compounds of simple

bodies are thus related to one another, it is the proto-compounds, or those containing single proportions, which are decomposable, and that the per-compounds are not so.

The second section contains an account of a new instrument devised by the author, for exactly measuring electric currents, and which he terms the *volta-electrometer*. The current to be measured is made to pass through water acidulated by sulphuric acid, and the gases evolved by its decomposition are collected and measured, thereby giving at once an expression of the quantity of electricity which has passed. The principle on which this conclusion is founded is the new law discovered by the author, "*that the decomposing action of any current of electricity is constant for a constant quantity of electricity.*" The accuracy of this law was put to the test in every possible way, with regard to the decomposition of water, by making the same current pass in succession through two or more portions of water, under very different circumstances: but whatever were the variations made, whether by altering the size of the poles or electrodes, by increasing or lessening the intensity of the current or the strength of the solution, by varying its temperature or the mutual distance between the poles, or by introducing any other change in the circumstances of the experiment, still the effect was found to be the same; and a given quantity of electricity, whether passed in one or in many portions, invariably decomposed the same quantity of water. No doubt, therefore, remains as to the truth of the principle on which the volta-electrometer acts: but with regard to the practical application of the principle, several forms of the instrument are described by the author, and the mode of employing them, either as the measurers of absolute quantities, or as standards of comparison, are fully pointed out.

In the third section of the paper, the primary or secondary character of the bodies evolved at the electrodes is discussed. It is shown that they are secondary in a far greater number of cases than has usually been imagined; and that laws have been deduced with regard to the ultimate places of substances, from the appearance of the secondary products; so that certain conclusions, true in themselves, have hitherto been obtained by erroneous reasoning, since the facts which were supposed to support them have, in truth, no direct relation with those conclusions. The methods of distinguishing primary and secondary results from each other are explained, and the importance of this distinction towards the establishment of the law of definite electro-chemical action is insisted upon by the author.

The fourth section is entitled, "*On the definite Nature and Extent of Electro-chemical Decomposition,*" and is considered by the author as by far the most important of this or indeed of the whole series of investigations of which he has now presented the results to the Royal Society. He adverts to the previous occasions on which he has already announced, more or less distinctly, this law of chemical action; and also to the instrument just explained as one of the examples of the principle about to be developed. He next refers to experiments described in another part, in which primary and secondary results are distinguished as establishing the same principle with regard to muriatic

acid ; the results showing, that not only the quantity of that acid decomposed is constant for a constant quantity of electricity, but that, when it is compared with water, by making one current of electricity pass through both substances, the quantities of each that are decomposed are very exactly the respective chemical equivalents of those bodies. The same current, for example, which can decompose nine parts by weight of water, can decompose thirty-seven parts by weight of muriatic acid, these numbers being respectively the chemical equivalents of those substances, as deduced from the phenomena of ordinary chemical action.

Cases of decomposition are then produced, in which bodies rendered fluid by heat, as oxides, chlorides, iodides, &c., are decomposed by the electric current, but still in conformity with the law of constancy of chemical action. Thus the current which could decompose an equivalent of water, could also decompose equivalents of muriatic acid, of proto-chloride of tin, of iodide of lead, of oxide of lead, and of many other bodies, notwithstanding the greatest differences in their temperature, in the size of the poles, and in other circumstances ; and even changes in the chemical nature of the poles or electrodes, and in their affinities for the evolved bodies, occasioned no change in the quantity of the body decomposed.

The author proceeds, in the last place, to consider a very important question with relation to chemical affinity, and the whole theory of electro-chemical action, namely, the absolute quantity of electricity associated with the particles or atoms of matter. This quantity he considers as precisely the same with that which is required to separate them from their combination with other particles when subjected to electrolytic action, and he brings many experiments to bear upon this point ; describing one, in particular, in which the chemical action of 32·5 parts of zinc, arranged as a voltaic battery, was able to evolve a current of electricity capable of decomposing and transferring the elements of 9 grains of water, being the full equivalent of that number. The relation of electricity, thus evolved, to that of the common electric machine is pointed out in a general way, and the enormous superiority as to quantity, in the former mode of action, is insisted upon. In conclusion, the author refers to a statement which he has made in the third series of these researches, in which he expresses his belief that the magnetic action of a given quantity of electricity is also definite ; and he is now more confident than ever that this view will be fully confirmed by future experiment.

The reading of a paper, entitled, "An Inquiry into the Nature of Death ; being an attempt to ascertain its more immediate causes, with a view to the better regulation of the means of obviating them." By A. P. W. Philip, M.D., F.R.S. L. & Ed.—was commenced.

February 20, 1834.

HIS ROYAL HIGHNESS THE DUKE OF SUSSEX, K.G.,
President, in the Chair.

The reading of Dr. Philip's paper was resumed and concluded.

The object of the present paper, which the author intends as a sequel to those he has lately presented to the Society, and which have been published in the *Philosophical Transactions*, is to investigate the operation of the different causes of death, and the mode in which the several powers of the living system influence each other during the period of their decline. In the more perfect animals, he observes, there are three distinct classes of functions, namely, the sensorial, the nervous and the muscular, which have no direct dependence on each other, although they are linked together by the connexions of the organs in which they reside; the consequence of which is, that the cessation of any one class of functions is more or less immediately followed by the destruction of the rest. What is commonly called *death* consists in the extinction of the sensorial functions only; for the nervous and muscular functions may still, for a time, survive; although, in consequence of the failure of respiration, which in the more perfect animals the author considers as, in the strictest sense, a function of volition, they also speedily terminate. Thus he distinguishes this sensorial death from what constitutes actual death, that is, the cessation of all the functions, and which occurs at a later period. As far as the sensorial powers are concerned, their decline and cessation are exceedingly analogous to the approach and occurrence of sleep; the only difference being that the former is an irrevocable failure of those powers, while the latter admits of their being resumed with renovated vigour by the continued action of the vital powers.

The modes in which the sensitive functions are extinguished, or in other words *the forms of death*, are referred by the author to five different heads: the first and only natural mode is that from the simple effect of old age, when all the powers of life are completely exhausted by the continued operation of the agents which had excited them; and death is, in that case, only the last sleep. The vital functions are here impaired, chiefly from the diminished frequency of respiration, which is itself a consequence of the impaired sensibility; so that there is a diminution of the action, but not of the powers, of the vital organs. If the decay of the vital powers be gradual, and nothing occurs suddenly to accelerate it, they will necessarily cease at the time when their excitement is the smallest, that is, during the state of sleep.

In all other cases, death arises from causes which must be regarded as adventitious, and consequently inducing a more or less violent death. The first class of these causes comprises those arising from the continued action of stimulants, more powerful than the ordinary stimulants to which the system is subjected, and making their immediate impression on the organs of the sensitive system. These may be considered as producing a diseased condition of the sensorium,

which, by sympathy, communicates its influence to the vital organs. The next form of death is that which is induced by such causes as are applied, in a sufficient degree, to act as direct sedatives to the organs of the sensitive system, that is, to impair their excitability without previous excitement. The third set of causes of death comprehends those which operate by depriving some of the vital organs of those stimulants on which their functions depend; and the last consists of such as directly debilitate those organs themselves. Thus, according to the author, these adventitious causes act either directly by destroying the power of the brain and spinal cord, or by affecting the vital parts of those organs, so as, through them, to destroy the circulation or the assimilatory functions. The destruction of the circulation appears, in all cases, to be the cause of instantaneous death, and always to be effected through impressions made on the vital parts of the brain and spinal cord, except where the injurious agent operates directly on the organs of circulation themselves.

The author considers the vital functions, together with the muscular and nervous powers, which carry them on, as the results of inanimate agents acting on living parts, or living parts on them; and hence he explains the analogy which exists between all these functions and the operations of inanimate nature; while, with regard to the sensorial functions alone, as they are the results of vital parts acting on each other, so no analogy can be perceived between them and those operations.

In the course of the paper the author frequently reverts to the argument, that, to the sentient being, death being simply the loss of sensibility, the last act of dying can in no case be an act of suffering: and in the majority of instances of the long continuance of disease, our tastes, and our relish for life itself, being gradually impaired, death is met, not only with composure, but even with satisfaction.

A paper was then read, entitled, "On the Tides." By John William Lubbock, Esq., V.P. and Treasurer of the Royal Society.

Various tables relating to the tides are communicated in this paper, calculated, according to the instructions of the author, by Mr. Dessiou. In the tables given by the author in former papers, already published in the *Philosophical Transactions*, and having reference to the corrections due to the influence of the parallax and declination of the moon, Mr. Dessiou employed only observations of the tides made between conjunction and opposition; but in those now given, similar corrections have been obtained from observations made between opposition and conjunction.

The author enters into an inquiry into the correction due to the calendar month, which is mixed up with that due to the moon's declination, and shows that the correction for the moon's parallax, as well as declination, deduced from the theory of Bernoulli, are quite discordant with the results of Mr. Dessiou's calculations, founded on actual observation.

The author agrees with Mr. Whewell in the remark, that the theory of the tides is now in the same state as that which the theory of the

motions of the moon and planets presented about a century ago ; and unless considerable exertions be made, it may so continue for many years to come. The tables of the planets have acquired their present accuracy only through the liberal encouragement of learned bodies, and of some of the governments of Europe ; nor can tables of the tides, adapted to the present state of science, be now constructed, unless very considerable expense be incurred, and immense labour bestowed.

The results of numerous observations on the influence of the wind on the tides in the River Thames, are stated ; and the author observes, that this is a subject of considerable importance as regards the accuracy of which tide predictions are susceptible.

The reading of a paper, entitled, " An Account of some Operations executed at Cape Frio, by the Officers and Crew of His Majesty's Ship *Algerine*, for the purpose of raising a part of the Stores, &c. lost in His Majesty's Ship *Thetis*." By the Hon. Commander F. T. de Roos, R.N., F.R.S.—was commenced.

February 27, 1834.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

The Hon. Commander de Roos's paper was resumed and concluded.

The author, who had the command of His Majesty's ship *Algerine*, was instructed to take charge of the enterprise commenced by the officers and crew of His Majesty's ship *Lightning*, having for its object the recovery of the treasure and stores from the wreck of the *Thetis*, which, in the month of December 1830, had sunk in a cove to the south-east of Cape Frio. He reached this spot on the 6th of March, 1832, having with him eleven officers and eighty-five men. A certain number of men were appointed to remain on board the ship, which was moored in a harbour two miles off ; a party of artificers and others were employed at the huts which they inhabited near the Cape ; and the rest, nearly thirty-five in number, were stationed at the wreck.

The author gives a description of Cape Frio, and of the island of which it forms the south-eastern extremity, and which is an immense promontory of insulated granite jutting into the Atlantic Ocean, sixty miles east of Rio de Janeiro. The cove, in the middle of which the wreck of the *Thetis* lay, is a square indenture in the cliffs, six hundred feet deep by as many wide. It is surrounded by nearly perpendicular masses of granite, from one hundred to two hundred feet high, and is exposed to the whole swell of the South Atlantic, which sets in with remarkable force in that direction. The weather is singularly variable ; and transitions frequently take place in the course of a few hours, from perfect stillness to the most tremendous swell. The author states that he has witnessed few scenes in nature more sublime than that presented by the *Thetis* Cove during a gale of wind from the south-west.

The author enters into a minute description of the mechanical apparatus employed for obtaining the necessary purchases for the various operations which were required, and gives a circumstantial history of his proceedings. Frequent interruptions were experienced from the state of the weather, and the almost incessant agitation of the water, which was often so powerful as to render the diving-bell unmanageable, and to expose the divers to serious danger. The diving-bell consisted of a one-ton ship's water-tank, with eight inches of iron riveted to the bottom in order to give it more depth, and having attached to it 18 pigs of ballast, the weight of which (17 cwt.) was found to be sufficient to sink it.

As soon as the necessary arrangements had been completed, the author states that he made a minute survey of the bottom, by means of the diving-bell, and ascertained the exact position and shape of all the large rocks which covered the spot where the treasures and stores of the *Thetis* had been scattered. The shape of the area where the precious metals in particular had been deposited, was an ellipse, of which the two principal axes measured 48 and 31 feet; and large boulders of granite had been subsequently rolled over these treasures, and required being removed before the latter could be recovered. The superincumbent pressure of the sea, aided by the huge materials of the wreck of the frigate, which, under the influence of the swell, acting like a paviour's hammer, with enormous momentum, had jammed together the rocks, and produced a strong cohesion between the fragments of wood, and the gold, silver and iron.

The first object was to clear away every portion of the wreck; and after this had been accomplished, to loosen and remove all the large rocks in succession, beginning with the smallest, and ending with the largest and most unwieldy. Some of these, which they succeeded in rolling from their situations into deeper water, weighed about thirty or forty tons; and the largest, which required the greatest efforts to move from its place, was computed to weigh sixty-three tons. This last effort served to show, that no part, either of the wreck or the stores, which was of any value, remained behind; and after fifteen-sixteenths of the property had been recovered, the enterprise, which had so perfectly succeeded, terminated on the 24th of July, and the *Algerine* returned to Rio de Janeiro on the 1st of August.

The author subjoins an account of the currents off Cape Frio, and a description of the climate, which seems to have been favourable, for his party suffered but little from sickness, and the expedition was unattended with the loss of a single life. On one occasion the party were visited by a whale, which approached very near the diving-bell, but fortunately changed its course, without doing any mischief.

A paper was then read, entitled, "An Account of a Concave Achromatic Lens, adapted to the Wired Micrometer, which has been named *Macro-micro*, from its power to increase the primary image of a Telescope without increasing the diameter of the wires in the Micrometer." By George Dollond, Esq., F.R.S.

The application of a concave achromatic lens to the wired micrometer of a telescope, arose out of the series of trials that were made for the purpose of correcting the aberrations of the eye-glasses applied to the telescope constructed by the author for the Royal Society, with a fluid-correcting lens, on the plan suggested by Professor Barlow. The concave lens, being interposed between the object-glass and the eye-glass, and being at the same time achromatic, combines the advantages of doubling the magnifying power, without a corresponding diminution of light, and without altering the apparent distances of the threads of the micrometer. The results of the trials made with telescopes to which this addition was made, are given in a letter to the author from the Rev. W. R. Dawes, of Ormskirk; from which it appears that Mr. Dollond's method was attended with complete success. Mr. Dawes states, that, in order to put its illuminating power to a severe test, he had examined with this instrument the satellites of Saturn and the minute companion of κ Geminorum, but could discover no decided difference in the apparent brightness of the former, allowance being made for the difference in the power employed; and the latter star was seen quite as distinctly with a much smaller power.

Extracts are subjoined from a letter of Professor Barlow's to the author, containing formulæ for the construction of the lens.

March 6th, 1833.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

The reading of a paper, entitled, "On the Structure and Functions of tubular and cellular Polypi, and of Ascidæ." By Joseph Jackson Lister, Esq., F.R.S.—was commenced.

March 13th, 1833.

JOHN WILLIAM LUBBOCK, Esq. M.A., V.P. and Treasurer, in the Chair.

The reading of Mr. Lister's paper was resumed and concluded.

This paper contains the account of a great number of observations made by the author during the last summer, while he was at the southern coast of England, on several species of *Sertulariæ*, *Plumulariæ*, *Tubulariæ*, *Campanulariæ*, *Flustræ*, and other polypiferous zoophytes, and also on various *Ascidæ*. Each specimen was placed for examination in a glass trough with parallel sides, before the large achromatic microscope of the author, directed horizontally; and care was taken to change the sea-water frequently, which was done by means of two syphons, the one supplying fresh water, while the other carried off the old; a plan which succeeded in keeping the animals in perfect health and vigour. The drawings which were taken of the

appearances that presented themselves were traced with a camera-lucida, slid over the eye-piece of the microscope.

In a specimen of the *Tubularia indivisa*, when magnified 100 times, a current of particles was seen within the tube, strikingly resembling, in the steadiness and continuity of its stream, the vegetable circulation in the *Chara*. Its general course was parallel to the slightly spiral lines of irregular spots on the tube; on one side flowing from, and on the other towards, the polypus, each current occupying one half of the circumference of the tube. The particles were of various sizes, some very small, others larger, but apparently aggregations of the smaller: a few were nearly globular, but in general they had no regular shape. At the knots, or contracted parts of the tube, slight vortices were observed in the current; and at the ends of the tube the particles were seen to turn round, and pass over to the other side. Singular fluctuations were also observed in the size of the stomach and of the cavity of the mouth; the one occasionally enlarging, while the other contracted, as if produced by the passage of a fluid from the one into the other and its subsequent recession, thus distending each alternately. This flux and reflux took place regularly at intervals of 80 seconds; besides which two currents were continually flowing, both in the mouth and stomach; an outer one in one direction, and an inner one in the opposite direction.

In all the species of *Sertulariæ* examined by the author, currents of particles were observed passing along the soft substance which occupies the axis of the stem and branches, and were even seen extending into the substance of the polypi themselves, and traversing the stomachs belonging to each. Contrary to what happens in the *Tubularia*, the stream does not, in these animals, flow in the same constant direction; but after moving towards one part for about a minute or two with considerable velocity, it becomes much slower, and then either stops or exhibits irregular eddies, after which it resumes its motion with the same velocity as before, but in the contrary direction; and so on alternately, like the ebb and flow of the tide. If the current be designedly obstructed in any part of the stem, those in the branches go on without interruption, and independently of the rest. It appears from a passage which the author has quoted from Cavolini, that he had noticed the circumstance of currents existing in the interior of *Sertulariæ*, but had not detected their continuation into the stomachs of the expanded polypi. Similar phenomena, which the author describes in detail, were observed in several *Campanulariæ* and *Plumulariæ*; and several particulars are noticed with regard to the ovaries, and to the movements of the fluids contained in the ova of these zoophytes, before their exclusion from the body of the parent. In some cases, the young polype, after it has attained a certain growth, but while still adhering to the parent, becomes decomposed, and, its substance being absorbed into the body of the latter, it entirely disappears. Changes of the same kind frequently take place in different parts of the whole group; one of the polypes being seen to shrink and gradually disappear, while others shoot forth in more luxuriant growth, rapidly acquiring a large size. The author regards the

circulating fluids in these animals as the great agent both in the absorption and the growth of parts, and throws out the suggestion, that as it flows into the stomach, it may also act as a solvent to the food received into that cavity. The particles which exist in these fluids show their analogy to those in the blood of the higher animals on the one hand, and to those in the sap of vegetables on the other: some appear to be derived from the digested food, and others from the melting down of parts absorbed. In these polypi the author never saw the least appearance of cilia, or of currents in the surrounding water, which are so frequently met with in other tribes of zoophytes.

The latter part of the paper is occupied by the account which the author gives of his various observations, first, on *Ascidia*, of which he enters into an anatomical description; secondly, on the internal currents of water, permeating the branchial sacs, and determined by the vibratory movements of cilia which are seen in that animal; and, thirdly, on the alternations in the course of the circulation of the blood in the vessels, which at one time flows in one direction, and, after a certain interval, takes the contrary course; so that the same vessel which at one time performs the function of an artery, performs, at another, that of a vein. This phenomenon of alternate currents, like that in the *Sertularia*, was met with in every specimen of *Ascidia* which was examined by the author, and also in a *Polyclinium*.

The paper concludes with several observations on *Flustra*, from which, as far as relates to the circulation of currents, the author was led to results in many respects analogous to the preceding.

A paper was then read, entitled, "On the Theory of the Moon." By J. W. Lubbock, Esq., V.P. and Treasurer of the Royal Society.

The author, adverting to the appearance of M. Plana's admirable work entitled *Théorie du Mouvement de la Lune*, enters into a comparison of the analytical methods employed by that author and M. Damoiseau, and points out some differences in the numerical values of the coefficients of some of the arguments in the expression for the true longitude of the moon in terms of her mean longitude. He then prosecutes the subject by a series of analytical investigations, which are not susceptible of abridgement, but from which he obtains formulæ which do not quite agree with those of M. Plana.

A paper was also read, entitled, "Some Suggestions relative to the best method of employing the new Zenith Telescope lately erected at the Royal Observatory." By John Pond, Esq., F.R.S., Astronomer Royal.

During the observations made by the author, in the course of last summer, with the new zenith telescope lately erected at the Royal Observatory, for the purpose of measuring the zenith distance of γ Draconis, it occurred to the author to avail himself of subsidiary observations on another star, of about the fifth magnitude, which has nearly the same zenith distance towards the south that γ Draconis has towards the north, and which passes the meridian between 20 and 30 minutes, in time, after it. The angular distance between the

two stars being determined in the usual manner, by observing them on the same night, and in the same position of the instrument, gives the *sum* of their zenith distances : and if on the next or some following night γ Draconis be observed, and after its passage the instrument be turned half round, and the other star observed, then the difference of the measure, as read on the micrometer, will be the *difference* of the zenith distances of the two stars. These sums and differences, thus ascertained on different nights, will be independent of any change that may happen to the instrument in the interval. This method affords the means of determining, with almost unlimited precision, the value of the small equations which become the subject of investigation in the employment of the instrument. Thus all changes of the position of the stars, occasioned by aberration, nutation, &c., will produce double the effect on the small differential or subsidiary angles, as measured by this method. For the investigations of these small equations it will not be necessary to have determined either the exact zenith distance of each star, or the exact difference of their zenith distances, or the absolute magnitude of this subsidiary angle ; its variation from time to time being the only important object of research. The author is led to expect that this property may, at some future period, be applied with advantage in investigations made with moveable zenith instruments.

March 20th, 1833.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

A paper was read, entitled, "Narrative of the Proceedings of Commander Thomas Dickinson, of His Majesty's Sloop Lightning, while employed in the Enterprise for the Recovery of the Public Stores and other property sunk in His Majesty's late Frigate Thetis, on the south-west side of the Island of Cape Frio." By Commander Thomas Dickinson, R.N. Communicated by P. M. Roget, M.D., and J. G. Children, Esq., Secretaries to the Royal Society. It was preceded by the reading of a letter from the author to the Secretary, explaining the reasons which induced him to lay this narrative before the Royal Society, and place on the records of its proceedings the information it contains relative to the commencement of an enterprise, wholly planned and undertaken by himself, and which, under his superintendence, was, by the great, persevering and meritorious exertions of his officers and crew, most successfully accomplished.

The narrative commences with the statement of the consternation produced at Rio de Janeiro on the receipt of the intelligence of the loss of the Thetis, with a freight of about 810,000 dollars, on the south-west side of the island of Cape Frio, and of the determination of the author, on finding that no one seemed disposed to take any step towards the recovery of the property thus lost, to make the attempt himself, if he could obtain from the Commander-in-chief at that

station, Rear-Admiral Thomas Baker, C.B., orders to that effect. He accordingly exerted himself to obtain every possible information relative to the nature of the coast, depth of water, and other circumstances, which might enable him to judge of the practicability of the undertaking, and of the means necessary for its successful accomplishment; and became convinced that the difficulties and obstacles to be encountered, although numerous and formidable, might be overcome by the employment of the means which suggested themselves to him as practicable on this occasion, if sufficient assistance were afforded him in putting them into execution. He accordingly had models of the proposed machinery made, and submitted them, together with his plans, to the Commander-in-chief, by whom they were approved. He experienced great difficulties in procuring a suitable diving-bell, for it was impossible to obtain any instrument of the kind at Rio de Janeiro, or even any facilities for the construction of one by casting. It at length occurred to him that a ship's iron water-tank might be converted to this use; and being supplied with one from the *Warspite*, he was enabled to render it available for that purpose. The next difficulty was to procure an air-pump, which, after much delay, owing to the tardiness of the native workmen in that country, was at length constructed. The want of air-hoses, however, was a still more formidable obstacle to the success of the plan; but the ingenious contrivances of the author for rendering the common pump hoses airtight, supplied this deficiency; and on a trial which he made with the whole apparatus on the 22nd of January, 1831, it was found to answer completely. The next day he received his orders from the Commander-in-chief, and, sailing on the following day, arrived at the harbour of Cape Frio on the 30th, and immediately proceeded to inspect the coast, and ascertain the situation of the wreck, not a vestige of which was visible. An account is then given of the local circumstances of the Thetis Cove, or inlet, surrounded by almost perpendicular cliffs from 108 to 194 feet in height, with a depth of water varying from $3\frac{1}{2}$ to 24 fathoms, and the bottom being strewed with huge perpendicular rocks, occasioning these inequalities. These surveys showed that the execution of the plan originally conceived by the author was opposed by so many unforeseen difficulties, that he was obliged to relinquish some parts of it, and resort to fresh expedients for surmounting them. The idea of constructing a derrick then occurred to him; but the materials were wanting, for no trees existed in the island except those in the forests in the interior, which were inaccessible from their distance and the heights on which they grew, and of which the wood was, from its quality, unsuitable to the purpose. His only resource, therefore, was to make it of the fragments of spars saved from the wreck. With great exertions, a circumstantial account of which is given in the paper, the work was at length accomplished; and the result fully equalled the anticipations which had been formed of its utility in affording a stable point of support for the operations with the diving-bell. Previously to the erection of a derrick, however, much had been done by working the diving-bell from a boat, and a considerable quantity of stores and treasure raised. At one time the anxiety

of the author to forward the undertaking, and avail himself of favourable weather, induced him to try the experiment of working by torch-light, which succeeded to a certain extent ; but after a few trials the danger was found to be excessive, and the fatigue to the divers so great as to oblige him to desist.

After the derrick had been for some time in operation, a tremendous sea arose, the shock of which, for want of sufficient materials to support it, effected its destruction ; and a substitute was then resorted to by the setting up of a suspension cable diagonally from the cliffs, which, after great difficulties, was at length effected.

A great portion of the narrative is occupied with the details of the various proceedings, and of the serious impediments which were successively overcome by the zeal, perseverance and extraordinary exertions of the officers and crew, under the orders of Captain Dickinson, subjected as they were, for so long a period, to the greatest privations and hardships, arising from the laborious nature of the work, the unhealthiness of the climate, the attacks of the chigger, producing distressing ulcers in the feet, the annoyance from drifting sand, which penetrated into every place, the exposure to constant wet in huts which could not be made to exclude either wind or rain, and the perils arising from the boisterous gales and tremendous swell of the sea, which the whole ship's company, but more particularly the men in the diving-bell, had to encounter ; forming a combination of difficulties which the author is convinced could have been surmounted by none but British seamen.

After having succeeded so far in the undertaking, and made, at various times, shipments for England of treasure amounting to about three fourths of the whole which had been on board the *Thetis* when she sunk, orders were received by the author, on the 6th of March, to resign the charge of the enterprise to the Hon. Capt. De Roos, of His Majesty's brig *Algerine* ; on the receipt of which he immediately ordered a survey to be taken of the stores, and on the 9th descended in the bell, surveyed the bottom of the Cove, ascertained the position of the remaining stores and a considerable quantity of treasure ; and after having communicated the whole of the results to Captain de Roos, instructed him, his officers and ship's company in the way of working the bell, as well as in the different modes of removing rocks, recovering stores and treasure, and the use of the whole of the machinery, and furnished him with every necessary information for his guidance, he lent twenty of his men to the *Algerine* for their assistance, resigned the charge to his direction on the 10th, and sailed for Rio de Janeiro on the 13th.

Annexed to the paper is a journal of the amount of treasure of various descriptions recovered between the 31st of March, 1831, and the 10th of March, 1832, by His Majesty's sloop *Lightning*.

There was then read an extract of the letter of instructions, bearing date the 10th of March, 1832, from Commander Thomas Dickinson, then of His Majesty's ship *Lightning*, to Commander the Hon. S. F. de Roos, then of His Majesty's brig *Algerine*, on the former re-

signing to the latter the charge and direction of the enterprise for the recovery of the public stores and treasures sunk in His Majesty's late frigate *Thetis*, off Cape Frio.

The Society then adjourned over the Easter Recess, to meet again on the 10th of April.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1833-1834.

No. 16.

April 10, 1834.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer,
in the Chair.

The Right Hon. Edwin Viscount Adare; Charles Ansell, Esq.; Felix Booth, Esq.; Lieut. Alexander Burnes, E.I.C.; Francis Corboux, Esq.; Sir William Browne Folkes, Bart., M.P.; James William Freshfield, Esq.; John Davies Gilbert, Esq., M.A.; Edward Griffith, Esq.; Edmund Halswell, Esq., M.A.; William Charles Henry, M.D.; Robert Hudson, Esq.; Rev. William Forster Lloyd, M.A.; John Phillips, Esq.; Captain Walter Nugent Smee, E.I.C.; William Spence, Esq.; Henry Sykes Thornton, Esq., M.A.; John Warburton, M.D.; and Horace Hayman Wilson, Esq., were elected Fellows of the Society.

A paper was read, entitled, "On a General Method in Dynamics, by which the Study of the Motions of all free Systems of attracting or repelling Points is reduced to the Search and Differentiation of one central Relation, or characteristic Function." By William Rowan Hamilton, Esq., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland. Communicated by Captain Beaufort, R.N., F.R.S.

After some introductory remarks illustrative of the scope and design of this paper, the object of which is sufficiently pointed out in its title, the author considers, 1st, the integration of the equations of motion of a system, the characteristic function of such motion, and the law of varying action; 2nd, the verification of the foregoing integrals; 3rd, the introduction of relative or polar co-ordinates, or other marks of position of a system; 4th, the separation of the relative motion of a system from the motion of its centre of gravity, the characteristic function for such relative motion, and the law of its variation; 5th, the systems of two points in general, and the characteristic function of the motion of any binary system; 6th, the undisturbed motion of a planet or comet about the sun, and the dependence of the characteristic function of elliptic or parabolic motion on the chord and the sum of the radii; 7th, the systems of three points in general, and their characteristic functions; 8th, a general method of improving an approximate expression for the characteristic function of motion of a system, in any dynamical problem; 9th, the application of the foregoing method to the case of a ternary or multiple system, with any

laws of attraction or repulsion, and with one predominant mass ; 10th, the rigorous transition from the theory of binary to that of multiple systems, by means of the disturbing part of the whole characteristic function, and approximate expressions for the perturbations.

A paper was also read, entitled, "Observations on the Motions of Shingle Beaches." By Henry R. Palmer, Esq., F.R.S.

The author states that the object of his inquiries is limited to the collection of such facts as may assist in establishing practical rules for controlling the motions of the beach, with a view, on the one hand, to the preservation of clear channels where such are wanted, and on the other, to the obtaining accumulations of shingles in situations where they may be useful. He considers the actions of the sea on the loose pebbles as of three kinds ; the first, which he terms the *accumulative action*, heaps up or accumulates the pebbles against the shore ; the second, or the *destructive action*, disturbs and breaks down the accumulations previously made ; and the third, or *progressive action*, carries the pebbles forwards in a horizontal direction. The causes of these actions are referable to two kinds of forces ; the one being that of the current, or the motion of the general body of the water in the ebbing and flowing of the tides ; and the other that of the waves, or that undulating motion given to the water by the action of the winds upon it.

He adduces many facts which show that it is not, as is generally believed, the currents which move the pebbles along the coast, the real agent being the force of the waves, the direction of which is determined principally by that of the prevailing winds, which, on the coasts of Kent and Sussex, where the author's observations were chiefly made, is from the westward. Every breaker drives before it the loose materials which it meets, throwing them up on the inclined plane on which they rest, and in a direction corresponding generally with that of the breaker. In all cases, the finer particles descend the whole distance with the returning breaker, unless accidentally deposited in some interstice ; but the larger pebbles return only a part of the distance, this distance having an inverse ratio to its magnitude. This process constitutes the accumulative action. Under other circumstances, on the contrary, depending on the quickness of succession of the breakers, pebbles of every dimension return the whole distance along which they had been carried up, and are also accompanied in their recession by other pebbles, which had been previously deposited ; and this constitutes the destructive action. This latter action is also promoted by a form of coast, such as that produced by rocks, tending to confine the returning waves in particular channels, whereby, being collected into streams instead of being broken and dispersed, they acquire, on the recoil, sufficient force to carry down the pebbles, and deposit them below the general surface. The author gives examples of these effects, from what he has observed in the neighbourhood of the harbours of Folkstone, Dover and Sandgate, and along the coast as far as the bay called Sandwich Flats ; accompanied by illustrative drawings.

On these principles, the author thinks it will readily appear why the various attempts hitherto made to divert the motion of the shingles to a distance from the general line of the shore, both at Dover and at Folkstone, have invariably failed; and he recommends, for the prevention of the evil of accumulation, the adoption of a more general system of management along the coast, in preference to the resorting to particular devices adapted exclusively to each particular case.

The reading of a paper, entitled, "On some Elementary Laws of Electricity." By W. SNOW HARRIS, Esq., F.R.S.—was commenced.

April 17, 1834.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

The reading of Mr. Harris's paper was resumed in continuation.

April 24, 1834.

DAVIES GILBERT, Esq., D.C.L., Vice-President, in the Chair.

The reading of Mr. Harris's paper was concluded.

For the purpose of determining several questions relative to the forces exerted by bodies in different states of electricity, the author contrived an electroscope of peculiar construction, and also an electrometer, both of which he minutely describes; and in order to obtain a unit of measure, in estimating the quantity of electrical accumulation, instead of transmitting the electricity evolved by the machine immediately from its conductor to the battery to be charged, he interposes between them a coated jar, furnished with a discharging electrometer, so that the quantity of charges that have passed through it may be estimated by the number of explosions occurring in the process of accumulation. By increasing or diminishing the distance between the discharging balls, the value of the unit may at pleasure be rendered great or small.

A series of experiments is described, showing that when a given quantity of electricity is divided among any number of perfectly similar conductors, the attractive force, as measured by the electrometer, is inversely as the square of that number; and if different quantities of electricity be communicated to the same conductor, their attractive forces are directly as the squares of those quantities.

The author observes that the electrical force exerted by one body on another is always diminished by the vicinity of a neutral body; an effect which is analogous to the operation of screens in diminishing the force of a revolving magnet on metallic disks, as noticed by him in a former paper, published in the Philosophical Transactions. It appears, thus, that there is, in all these cases, a portion of electricity, which is masked, and not appreciable by the electrometer.

The author proposes to distinguish the terms *tension* and *intensity*, as applied to electricity; expressing by the first, the actual elastic force of a given quantity, accumulated in a given space; and by the second, the action of that part which is in a state of freedom, and which is indicated by its effects on the electrometer.

Experiments are next related, which were made for the purpose of showing the incorrectness of the explanation of the above fact proposed by Mr. Singer, namely, that it depends on the electrical action of the atmosphere. In the transmission of electricity between conductors placed at a distance, the quantity required to produce a discharge is directly as the distance; and conversely, the distance is directly as the quantity. This distance will, therefore, be a measure of the tension; whereas the attractive force, as indicated by the electrometer, is a measure of intensity only. Another conclusion deduced from this train of reasoning is, that the resistance of the atmosphere to the passage of electricity is not really greater through any one discharging distance than through another, and is in no case greater than the existing atmospheric pressure; and it was found by direct experiment, that the distance through which a given accumulation of electricity could be discharged, is inversely as the density of the interposed air. When this air preserved its density unaltered, the elevation of its temperature produced no difference in its power of controlling the escape of electricity; hence it is concluded that heated air is no otherwise a conductor of electricity, than in as much as it has thereby become rarefied; but heat applied to solid conductors was found to diminish their conducting powers.

The electrical capacities of conducting bodies of different shapes was the subject of inquiry. In plates having the form of parallelograms, the relative capacities, when the areas are constant, are inversely as the sum of the length and breadth; and when this latter sum is constant, the capacity is inversely as the area. The capacity of a plane circle differs but little from that of a square having the same area; nor does it make any difference if the plates be turned into cylinders, or prisms with any number of sides; and the capacity of a sphere or cylinder is the same as that of a plane equal to it in superficial extent.

The author proceeds to investigate some laws relating to the action of electricity, when resulting from induction; and particularly that of the relation between electrical attraction and distance; adducing experiments in confirmation of the former being in the inverse duplicate ratio of the latter. The attraction actually exhibited between two equal spheres, he considers as composed of a system of parallel forces, operating in right lines between the homologous points of the opposed hemisphere. The author concludes by various observations on the transmission of electricity to bodies in *vacuo*, from which he infers the fallacy of all explanations of the phenomena of electrical repulsion, founded on the supposed action of the atmosphere.

The reading of a paper, entitled, "On the Generation of the Marsupial Animals; with a Description of the impregnated Uterus of the

Kangaroo." By Richard Owen, Esq., Member and Assistant Conservator of the Museum of the Royal College of Surgeons, London. Communicated by Sir Anthony Carlisle, F.R.S.—was commenced.

May 1, 1834.

BENJAMIN COLLINS BRODIE, Esq., Vice-President, in the Chair.

Mr. Owen's paper was resumed, and concluded.

The author gives a history of the opinions which have been advanced relative to the generative organs and functions of the *Marsupialia*, an extensive order of quadrupeds, including animals nourished by every variety of food, and exercising very different powers of progression, yet exhibiting a remarkable uniformity in their mode of reproduction. In all the genera included in this family, the uterus is double; in most of them the vagina is also double; and there is always a single cloacal outlet for the excrementitious substances, and the products of generation. There is a corresponding uniformity in the male organs, which are bifurcated at the extremity, and have a double groove for the transmission of the semen; and the male has not only marsupial bones, similar to those of the female, but also a muscle, similar to that which surrounds and compresses the mammary gland in the female, winding round these bones like pulleys, and acting as cremasters for the retraction and compression of the testes.

A minute description is then given of the results of the dissection of the impregnated uterus of a kangaroo, which was obtained by Mr. George Bennett, during a short residence in New South Wales, and which, together with the impregnated uteri of the *Ornithorhynchus* and other valuable specimens, were sent to the Museum of the Royal College of Surgeons. The membrane corresponding to the chorion, or external envelope of the foetus, was found not to have a vascular structure, and not to adhere in any part to the surface of the uterus; neither was there any appearance of a placental or of a villous structure. It adhered internally to a vascular membrane, into which the umbilical stem of the foetus suddenly expanded, and which terminated in a well-defined ridge, formed by the trunk of a terminal blood-vessel. The three omphalo-mesenteric, or vitelline vessels, were traced, from the umbilical cord into the abdomen, where they terminated in the usual manner; namely, the veins in the vena portæ, and the artery in the aorta. Hence it was apparent that the membrane on which they ramified, corresponded to the vascular layer of the germinal membrane, which, in oviparous animals, spreads over the yolk, or to the umbilical vessel of the embryos of ordinary mammalia. The ventricles of the heart were completely joined together, and bore the same proportions to each other as in the adult; a perfection of structure which is not observed in the embryos of ordinary mammalia at a corresponding period of developement. The lungs were equal in size to the heart, and were of a spongy texture, and full of red blood; their precocious developement, compared with that of the abdominal or di-

gestive organs, being evidently a provision for their early or premature exercise.

From the close resemblance in the structures of the ovary and Fallopian tubes of the kangaroo with those of ordinary mammalia, and from the circumstance of the young being nourished, after birth, by a secretion from mammary glands, the author concludes that the ovulum in the former animal quits the ovisac in a condition corresponding to that in the latter class, and increases in a similar manner as it descends to the uterus. But as there is no formation of a placenta, it remains to be determined how the aeration of the foetal blood is effected: this, however, probably takes place through the chorion, although this membrane is not vascular, to an extent sufficient for the purposes of the vital functions of a foetus so imperfect, and whose uterine existence is of such short duration, as they are in this animal. Reasons are given, which render it probable that in the Marsupialia allantois and umbilical arteries are developed at a later period of gestation, corresponding in this respect to the foetal condition of the Batrachian reptiles, and corroborating the views entertained by the author, that the former family are essentially ovo-viviparous.

The author next proceeds to investigate the structure and condition of the mammary foetus in the Marsupialia, or that stage of its existence when it is retained in the marsupial pouch, and derives its sustenance from the imbibition of milk from the mammary glands. He relates the observations which he has lately made on the foetus of a kangaroo in the Menagerie of the Zoological Society. He ascertained that the period of uterine gestation in the animal is thirty-nine days, and examined the foetus a few hours after it had fixed itself to the nipple in the abdominal pouch, and when it was not much above an inch in length, and resembled an earth-worm, both in the colour and the semi-transparency of its integument. Four days afterwards, he detached it from the nipple, and observed that although it moved its limbs freely, it was unable to regain its former situation. The parent endeavoured to replace it by introducing its head into the pouch, which it held open with its fore paws; but these efforts were ineffectual, and the next day the foetus had disappeared, having, probably, been destroyed by the mother.

The last section of the paper is occupied by an inquiry into the structure and analogies of the female generative organs of the Marsupialia. These are traced throughout the successive orders of mammalia, to their connexions with various tribes of birds and reptiles, and is concluded by a disquisition on the final purposes of marsupial generation, and its relations to the other modes by which the continuance of the race is accomplished, in the more elevated orders of animals, and which appear to have reference to the greater expansion and perfection of the brain, and the greater developement of the intellectual faculties.

A paper was then read, entitled, "On a new Law of Combustion." By Charles J. B. Williams, M.D. Communicated by W. G. Maton, M.D., F.R.S.

The principal object of this paper is to prove that most combustible bodies undergo a kind of combustion, attended with light and heat, at a temperature considerably below that usually assigned as their point of ignition. This fact has been already noticed with regard to phosphorus and sulphur; and the pale blue flame produced in the vapour of ether by a hot palladium or platina wire, before the wire itself becomes vividly ignited, is another instance of the same general law, which the author finds applicable to all compound, and a few of the simple inflammable bodies. Of these he gives a variety of examples among oleaginous, resinous, and carbonaceous products, both animal and vegetable, which, when thrown on a hot iron, exhibit a pale and faintly luminous flame. Those on the other hand which are very volatile, such as camphor, the essential oils, ether and alcohol, rise in vapour before they reach the temperature necessary for their combustion; but they may be made to exhibit the same phenomena, by directing their vapour against a body heated below redness. The contact of pure oxygen gas immediately heightens the intensity of the light and heat evolved on these occasions, and excites them into a more decided and vivid combustion.

The author next adverts to the nature of the products of this low form of combustion, which, in organic substances, appear to him to form an intermediate link between those of open combustion, and those of fermentation and putrefaction. He considers the phenomena he has described as confirming the truth of a law he formerly announced, namely, that "the evolution of heat during chemical change is, *cæteris paribus*, proportionate to the degree of change from isolation, or weak combination, towards firm and simple union." He thinks they will afford an explanation of many cases of spontaneous combustion, which have hitherto been involved in mystery; such as that of porous combustible matters, as oily cotton, tow, or wool, when accumulated in considerable quantities, in places protected from cooling, or where air has limited access; and also of heaps of coal or charcoal, of pyrophori and pyrites; and the same principles may perhaps also account for the phenomena of the spontaneous combustion of the human body which are on record.

May 8th, 1834.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

A paper was read, entitled, "On the Connexion between Refracted and Diffracted Light." By Paul Cooper, Esq. Communicated by J. G. Children, Esq., Sec. R.S.

The purport of the present paper, as stated by the author, is to connect the phenomena of the dispersion of light arising from refraction, with that consequent upon diffraction, by showing, 1st, "that white refracted light is formed by the superposition of fringes of colours, or rays of light uniformly refracted, which compensate each other in succession; 2nd, that diffracted white light is formed by the superpo-

sition of fringes which are not uniformly refracted, but which recede from it so gradually, as not to prevent the same mutual compensation, although it is distinguished by other appearances ; and 3rd, that the purity of the colour of the light, in both cases, depends upon its continuity, any interruption of which, although the different portions into which it may be separated are white at the moment the division takes place, produces colours in its further progress, because each portion carries with it the difference of direction required for their development."

A paper was also read, entitled, "Observations on the Reciprocal Influence which Magnetic Needles exercise over each other, when placed at a given distance within their respective Spheres of Action, at different positions on the Earth ; with Tables of numerical Results obtained at separate Stations. Also a method of discovering where certain local influences are acting on the Needle, from which may be obtained a proportional correction to be applied to Magnetic Observations in general." By Edward J. Johnson, Esq., Commander R.N. Communicated by Francis Beaufort, Esq., Capt. R.N., F.R.S.

The author, considering it probable that two or more magnetic needles freely suspended at a certain distance in given positions with respect to each other, would develop certain proportionate deflections determined by their position on the earth, made a set of experiments, with a few common compass needles, at Yarmouth, London, and Clifton, which so far confirmed the truth of his conjecture, as to induce him to fix on stations at a greater distance from one another, and to multiply his observations ; ascertaining, from time to time, that the magnetic powers of his apparatus had undergone no material change. The results of these observations are given in a tabular form.

The author conceives that comparative observations of the amount of deflection produced by one magnet on another, placed in various situations, relative to the meridian, on an horizontal plane, will afford the means of determining the peculiar local influences of the particular situation in which the experiment is made, as distinguished from the general magnetic influence ; because the former will act unequally on each magnet, while the latter acts equally on all.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1833-1834.

No. 17.

May 15, 1834.

MARK ISAMBARD BRUNEL, Esq., Vice-President, in the Chair.

A paper was read, entitled, "Of the Functions of some parts of the Brain; and of the relations between the Brain and Nerves of Motion and Sensation." By Sir Charles Bell, K.H., F.R.S.

The author commences his paper by an enumeration of some of the sources of difficulty and of error which have impeded the progress of discovery in the physiology of the brain; the first impediment to which, he observes, "is in the nature of the inquiry, since extraordinary and contradictory results must be expected from experimenting on an organ so fine as that must be which ministers to sensibility and motion, and which is subject to change on every impression conveyed through the senses." Another cause of fallacy is the dependence of the brain on the condition of the circulation within it: but the most frequent source of error is the obscurity which hangs over the whole subject; for although the brain be divided naturally into distinct masses, not one of these grand divisions has yet been distinguished by its functions; and hence we may account for the failure of all attempts to explain the phenomena which attend injury of the brain. The principle, now universally admitted, that nerves have distinct functions, and not a common quality, is pursued by the author in his investigation of the structure of the brain, in which he follows the nerves into that organ, and observes the tracts of nervous matter from which they take their origin. He concludes from his inquiries that both sensibility and motion belong to the cerebrum; that two columns descend from each hemisphere; that one of these, the anterior, gives origin to the anterior roots of the spinal nerves, and is dedicated to voluntary motion; and that the other, which from its internal position is less known, gives origin to the posterior roots of the spinal nerves, and to the sensitive root of the fifth nerve, and is the column for sensation. He further shows that the columns for motion, which come from different sides of the cerebrum, join and decussate in the medulla oblongata; that the columns of sensation also join and decussate in the medulla oblongata; and lastly, that these anterior and posterior columns bear, in every circumstance, a very close resemblance to one another, in as much as the sensorial expansions of both are widely extended in the hemispheres; for they pass through similar bodies towards the base of the brain, and both

concentrate and decussate in the same manner; thus agreeing in every respect, except in the nervous filaments to which they give origin. Hence he explains the phenomena of the loss of sensibility as well as the power of motion of one side of the body, consequent on injuries of the other side of the brain.

The Society then adjourned over Whitsun Week to the 29th of May.

May 29, 1834.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer,
in the Chair.

A paper was read, entitled, "On the Principle of Construction and General Application of the Negative Achromatic Lens to Telescopes and Eyepieces of every description." By Peter Barlow, Esq., F.R.S.

This paper is intended as a more full illustration of the principles on which the negative achromatic lens is constructed and applied, than has been given in the extract from the author's letter to Mr. Dollond, contained in the paper of the latter, lately read to the Society, on his ingenious application of that lens to the micrometer eyepiece. The author shows that its advantages are not confined to this instrument, but that it is applicable to any eyepiece positive or negative to the erecting eyepiece, and, indeed, to any telescope of fluid or glass, and also to refractors.

A paper was also read, entitled, "Some remarks in reply to Dr. Daubeny's Note on the Air disengaged from the Sea over the site of the recent Volcano in the Mediterranean." By John Davy, M.D., F.R.S. Assistant Inspector of Army Hospitals.

Respecting the air in question, which Dr. Davy had found to consist of about 80 per cent. of azote and 10 oxygen, he had remarked that two views might be taken of its origin; the one, that it was of volcanic source; the other, that it was derived from the sea water, and merely disengaged by the heat of the volcano. Dr. Davy, rejecting the former of these views, had adopted the latter, for reasons, the validity of which was controverted by Dr. Daubeny; and the purpose of the present paper is to answer the objections urged against them, and to bring additional evidence in support of his opinion.

A paper was then read, entitled, "On the number of Primitive Colorific Rays into which White Light may be separated." By Paul Cooper, Esq. Communicated by J. G. Children, Esq. Sec. R.S.

From a consideration of the circumstances in which white light is decomposed by the prism, in different experiments, and of the various appearances of the spectra which result, the author is led to the opinion that the primary colours composing white light are not seven, as conceived by Newton; nor four, as supposed by Wollaston; but only three: and that these three are not red, yellow, and

blue, as imagined by Brewster, but red, green, and violet; the first and last forming the terminal parts of the spectrum, and the green occupying an intermediate position; and the various tints which intervene being the result of superpositions, in various quantities, of these respective primary colours. He pursues the consequences of this hypothesis, applying it to a great variety of forms of experiment, not only by the direct observation of beams of refracted light, but by viewing the prismatic spectrum through different media, capable of absorbing each of the primitive colours in different degrees: and he finds the results to accord exactly with the hypothesis he proposes, and on which he therefore concludes that their true explanation must be founded. He conceives that the errors of preceding experimentalists have arisen from their neglecting to take into account the effects of diffraction, which introduces considerable confusion into the results.

A paper was also read, entitled, "An Investigation of the Laws which govern the Motion of Steam-Vessels, deduced from experiment." By P. W. Barlow, Esq. Civil Engineer. Communicated by Dr. Roget, Sec. R.S.

The author commences with the description of a paddle-wheel for steam-vessels, of a new construction, in which the floats are made to enter and leave the water nearly in a vertical position. He then investigates several formulæ adapted to the calculation of the forces and velocities arising from this form of the apparatus; and gives an account of the results of various experiments made on its efficiency as compared with the common wheels, and with relation to the consumption of fuel. The general results to which he is led are as follow:—1st. When vessels are so laden as that the wheel is but slightly immersed, little advantage is derived from the vertically acting paddles. 2ndly. In cases of deep immersion, the latter has considerable advantage over the wheel of the usual construction. 3rdly. In the common wheel, while the paddle passes through the lower portion of the arc, that is when its position is vertical, it not only affords less resistance to the engine, but is less effective in propelling the vessel than in any part of its revolution. 4thly. The paddle of the wheel, while passing through the lower portion of the arc, affords more resistance to the engine, and is more effective in propelling the vessel, than in any part of its revolution; a property which is a serious deduction from its value; for, in consequence of the total resistance to all the paddles being so much less than in the common wheel, much greater velocity is required to obtain the requisite pressure, and a greater expenditure of steam power is incurred. This loss of power is most sensible when the wheel is slightly immersed; but in cases of deep immersion the vertical paddle has greatly the advantage. 5thly. In any wheel, the larger the paddles the less is the loss of force; because the velocity of the wheel is not required to exceed that of the vessel in so great a degree, in order to acquire the resistance necessary to propel the vessel. 6thly. With the same boat and the same wheel no advantage is gained by reducing the paddle so as to

bring out the full power of the engine ; the effect produced being simply that of increasing the speed of the wheel, and not that of the vessel. 7thly. An increase of speed will be obtained by reducing the diameter of the wheel ; at least within such limits as allow of the floats remaining sufficiently immersed in the water ; and provided the velocity of the engine does not exceed that at which it can perform its work properly. 8thly. An advantage would be gained by giving to the wheel a larger diameter, as far as the immersion of the paddles produced by loading the vessel would not so sensibly affect the angle of inclination of the paddle ; but this advantage cannot be obtained with an engine of the same length of stroke, because in order to allow the engine to make its full number of strokes, it will then be necessary to diminish the size of the paddles, which is a much greater evil than having a wheel of smaller diameter with larger paddles.

The reading of a paper was then commenced, entitled, "On the Equilibrium of a Mass of Homogeneous Fluid at liberty." By James Ivory, Esq., K.H., M.A., F.R.S.

June 5, 1834.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

John Marquess of Breadalbane ; Charles John Lord Teignmouth ; the Hon. George Elliot, R.N. ; the Rev. Frederick William Hope, M.A. ; Joseph Jekyll, jun., Esq., M.A. ; the Rev. Robert Murphy, M.A. ; the Hon. Sir George Rose ; Richard Twining, Esq. ; William Robert Whatton, Esq. ; and George Witt, M.D., were elected Fellows of the Society.

Mr. Ivory's paper, entitled, "On the Equilibrium of a Mass of Homogeneous Fluid at liberty," was resumed and concluded.

The author shows that Clairaut's theory of the equilibrium of fluids, however seductive by its conciseness and neatness, and by the skill displayed in its analytical construction, is yet insufficient to solve the problem in all its generality. The equations of the upper surface of the fluid, and of all the level surfaces underneath it, are derived, in that theory, from the single expression of the hydrostatic pressure, and are entirely dependent on the differential equation of the surface. They require, therefore, that this latter equation be determinate and explicitly given ; and accordingly they are sufficient to solve the problem when the forces are known algebraical expressions of the co-ordinates of the point of action ; but they are not sufficient when the forces are not explicitly given, but depend, as they do in the case of a homogeneous planet, on the assumed figure of the fluid. In this latter case, the solution of the problem requires, farther, that the equations be brought to a determinate form by eliminating all that varies with the unknown figure of the fluid ; and the means of doing

this are not provided for in the theory of Clairaut, which tacitly assumes that the forces urging the interior particles are derived from the forces at the upper surface, merely by changing the co-ordinates at the point of action. In the case of a homogeneous planet, the forces acting on the interior particles are not deducible, in the manner supposed, from the forces at the surface.

After showing that the equilibrium of a fluid, entirely at liberty, will not be disturbed by a pressure of the same intensity applied to all the parts of the exterior surface, the author considers the action of the forces upon the particles in the interior parts of the body of the fluid; and shows that although the forces at the surface are universally deducible from the general expressions of the forces of the interior parts, yet the converse of this proposition is not universally true, the former not being always deducible from the latter; a distinction which is not attended to in Clairaut's theory. He then investigates the manner in which these two classes of forces are connected together; establishes a general theorem on the subject; and proceeds to its application to some of the principal problems, relating to the equilibrium of a homogeneous fluid at liberty, and of which the particles attract one another with forces, first in the inverse duplicate ratio, and secondly in the direct ratio of the distance, at the same time that they are urged by a centrifugal force arising from their revolution round an axis. The author concludes with some remarks on Maclaurin's demonstration of the equilibrium of the oblate elliptical spheroid; and on the method of investigation followed in the paper published in the Philosophical Transactions for 1824. In an Appendix the author subjoins some remarks on the manner in which this subject has been treated by M. Poisson.

The reading of a paper was then commenced, entitled, "Experimental Researches in Electricity;" Eighth Series." By Michael Faraday, Esq., D.C.L., F.R.S.

June 12, 1834.

BENJAMIN COLLINS BRODIE, Esq., Vice-President, in the Chair.

A paper was read, entitled, "On the Arcs of certain Parabolic Curves." By Henry Fox Talbot, Esq., M.P., F.R.S.

The general equation to parabolic curves, (namely, $nu = v^n$; where u is the abscissa and v the ordinate,) gives for the arc of the curve an expression which, excepting in a very few instances, is transcendental. But although the length of an arc, considered by itself, cannot be assigned algebraically, yet it frequently happens that the sum of two or more arcs is capable of being so assigned, and sometimes in a very simple manner. The author has found this reduction to take place in so many instances, as to incline him to believe that it may be universally possible, provided the exponent (n) of the ordinate in the equation to the curve is a rational quantity of these reductions: he

gives a great number of examples ; but although the processes for that purpose are easy, the difficulty consists wholly in finding the proper method of treating each individual case. The author hopes to lay before the Society, on a future occasion, an account of the principles on which this branch of analysis is founded.

Mr. Faraday's Eighth Series of Experimental Researches in Electricity was resumed and read in continuation.

June 19, 1834.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

The reading of Mr. Faraday's Eighth Series of Experimental Researches in Electricity was resumed and concluded.

This series is devoted to an investigation of the source, character and conditions of the electricity of the voltaic instrument, and is divided into five parts. In the first part, simple voltaic circles are considered ; and at the outset, the great question of "whether the electricity is due to contact or chemical action ?" is investigated and decided by apparently very conclusive evidence in favour of the latter. One principal experiment in favour of this decision is the following : A plate of zinc and a plate of platina were prepared ; one end of each of these was put into a vessel containing a little dilute sulphuric acid or sulpho-nitric acid, and between the other ends was placed a piece of bibulous paper moistened in a solution of iodide of potassium : the two plates did not touch each other anywhere, but still the action of the end at the one extremity was able to induce the electro-chemical decomposition of the iodide of potassium at the other. That this decomposition was due to the chemical action of the acid was proved by removing the latter ; for then the decomposition ceased. It was also farther proved by the appearance of the iodine against the *platina* ; for it went there in consequence of the passage of a current (induced by the action of the acid) having the opposite direction to that which the solution of iodide would have produced had it been the only exciting body, and metallic contact had been allowed.

The opposition of the chemical affinities at the two places where the acid and the solution of the iodide are placed, is shown when the metal plates are allowed to touch each other in the middle ; for then two opposite electric currents are produced, but that occasioned by the acid is the stronger. This opposition is farther shown in the manner in which the weaker set of affinities are overcome by the stronger (that is, those of the iodide and zinc by those of the acid and zinc) ; and this dependence and relation of the two explains at once the value of metallic contact ; for if the solution of iodide of potassium be placed between platina and platina, one of those pieces of metal touching the zinc which is immersed in the acid, then the solution of iodide does not tend to throw an electric current into circulation, because it exerts no chemical action in either direction ; and therefore

the powers active in the acid are more free to act, produce a stronger current, and effect decomposition more freely.

The chemical actions at the opposite ends of the metallic arrangement are so strongly associated and related, that in the most perfect form of experiment, action cannot occur at either end without also taking place at the other extremity to an exactly equivalent amount. This is considered by the author as the most convincing proof that in the voltaic pile the chemical and electric action are the same; that is, modes of exhibition of the same force, and as they are convertible into each other in exactly definite proportion, must have one common origin.

By using different fluids at the exciting place of action, currents of different intensity could be obtained: thus the current produced by the action of dilute sulphuric acid on zinc and platina could decompose elsewhere solution of iodide of potassium, fused protochloride of tin, or chloride of silver; but could not decompose water, muriatic acid, nitric, or the chloride or iodide of lead. Making the dilute sulphuric acid stronger, or using larger plates of zinc and platina, did not yield any advantage; but immediately that the chemical action on the zinc was increased in *intensity*, which could be done by adding only a few drops of nitric acid, then most of the latter bodies could be decomposed by a single pair of plates. A scale of initial intensities can in this way be obtained.

The electricity evolved in the voltaic pile is altogether due to that chemical action which takes place between the metal most easily acted upon and the element which unites with it; as, for instance, between the zinc and the oxygen of the water, or the chlorine of the muriatic acid, or the sulphur of hydrosulphurets, &c.; the after action of the acid in combining with the oxide, when that is the substance formed, adds nothing to the effect. The truth of this principle is deduced in the first place from the electricity evolved being the equivalent of the zinc oxidized; in the second, from the quantity of electricity being the same for the oxidation of a given quantity of zinc, whether the oxide formed is removed by an acid or an alkali; and it is supported by many other experimental reasons and proofs.

The view which the author takes of the identity of electrical and chemical action, leads him to admit that there are *two modes of action* in which the attractive power of the substances which ultimately combine, and by combining give the voltaic pile activity, can be exerted. Thus, taking zinc and platina as the two metals used, then the *third* substance must be an electrolyte; that is, a body which is decomposed when the electric current passes it; which cannot conduct the current unless it is at the same time decomposed; and which contains an element having such attraction for the zinc that the latter can take it from the element with which it is previously combined. Water is the electrolyte generally present in the voltaic pile.

Then, with respect to the attraction between the zinc and the oxygen of the water, we have it in our power to cause it to take place at once when the metal and water are in contact, the hydrogen being then set free; or we can, by using the precautions which the author

gives, cause that no action take place, unless a current be formed and the hydrogen be transferred to a distance, whilst the forces circulate in what is called the electric current. Placing the origin of the current in the chemical action, which yet could be thus virtually restrained unless the circuit was completed, the author expected to find a state of tension in the chemical or electrical forces *before* metallic contact was made or the circuit perfect, and was able at last to prove this most fully by obtaining an *electric spark* between two plates of different metals immersed in acid before they came in contact. This fact, with the former one of decomposition, fully proved that contact was not necessary to the production of the electricity in the voltaic pile.

The *second* part of this memoir contains an investigation of the following important points: namely, whether electrolytes could resist the action of an electric current if below a certain intensity; whether the intensity at which an electric current might cease to act would be the same for all bodies; and also whether the electrolytes, when thus resisting decomposition, would conduct the electricity as a metal or charcoal does, after they ceased to conduct as electrolytes, or would act as insulators. It is first proved with regard to water, that a current of a certain intensity is necessary for its decomposition, but that a current of a lower intensity is conducted by it; and that with such feeble currents, pure water conducts as well as acidulated water or saline solutions. The same condition of a certain necessary intensity of current was found to hold good also with sulphate of soda in solution with fused chloride of lead and other bodies, and is considered by analogy as extending to all electrolytes.

In the *third* part of the paper, associated voltaic circles, or the voltaic battery, is examined. From the principles and facts stated in the preceding parts, it appears evident that the association of many pairs of plates, equal in size, nature and force, cannot by any possibility increase the quantity of electricity above that which any single pair in the series could produce, taking the quantity of zinc oxidized at any one plate as the standard of development. It is easy, by using amalgamated zinc, to construct a battery in which no action shall take place on the metals, except the extremities be in communication. If a battery of ten pairs of plates be thus communicated, there is of course oxidation of each zinc plate, and a current of electricity circulates. If the contact of the extremities be continued until a certain quantity of zinc has been dissolved at any one plate, it will be found that an exactly equal quantity has been dissolved at each of the other plates; and that a certain quantity of electricity has passed, which can be taken cognizance of by the volta-electrometer. But should nine of the pairs of plates be removed and the battery be reduced to a single pair, yet when the given quantity of zinc had been dissolved there, as much electricity would have gone round the circuit as with the whole number of ten pairs, and during the evolution of which ten times the quantity of zinc had been oxidized.

This result, already proved by electro-magnetic experiments, is shown to be a necessary consequence of the construction of the pile and the manner in which its forces act. The electricity evolved by

chemical action at one pair of plates cannot pass by another pair except an equal chemical action take place there; and as the chemical and electrical action are always equivalent, the equal chemical action at the second pair will do no more than suffice to transfer forwards the forces disturbed at the first pair, and can add nothing to their quantity: but they can add to their *intensity*, and in fact the recurrence of a second chemical action at the second pair of plates has exactly the same effect as would be produced by a more intense chemical action at the first pair. In this way it is that numbers of plates give energy to the voltaic pile, and enable its power to penetrate electrolytic bodies and permeate bad conductors in a manner which could not be done by the electricity of a few pairs of plates only.

The *fourth* part of the paper relates to the resistance opposed to the electric current at the place of decomposition, and refers this at once to the resistance of the chemical affinity which has to be overcome. This of course varies with the number of places where decomposition is effected, the strength of the affinity of the elements of the decomposing body for each other, and the nature of the substance against which the decomposition is effected, and by which it may very frequently be assisted. All these are taken into account, their general, and occasionally particular, results shown, and their perfect harmony with the principles previously advanced pointed out.

In the last part of the paper some general remarks on the active voltaic battery are made, in which the influence of several distinct causes in producing a rapid change and deterioration of action is pointed out. Each of these causes is considered separately, and the effects they produce are shown to be necessary consequences of the principles already laid down as those of the voltaic battery.

The following Papers were then read:

1. "Observations on the *Teredo navalis* and *Limnoria terebrans*, as at present existing in certain localities of the British Islands." By William Thompson, Esq., Vice-President of the Natural History Society of Belfast. Communicated by J. G. Children, Esq. Sec. R.S.

The opinion which has been advanced, that the *Teredo navalis* is no longer to be found on the British coast, is shown by the author to be erroneous; for numerous specimens of that destructive animal, collected from the piles used in the formation of the pier at Portpatrick in Ayrshire, were furnished to him by Captain Frayer, R.N. (of His Majesty's Steam-packet Spitfire). Some of these specimens had attained the length of nearly two feet and a half, a magnitude at least equal to, if not exceeding, the largest brought from the Indian seas. After giving a description of the animal, the author enters into an inquiry into the agency it employs to perforate the timber which it consumes as food, and in which it establishes its habitation. He ascribes to the action of a solvent, applied by the proboscis, the smooth and rounded termination of its cell, which is afterwards enlarged by the mechanical action of the primary valves.

The author then gives an account of the natural history and opera-

tions of another animal, the *Limnoria terebrans*, of Leach, belonging to the class of Crustacea, whose depredations on timber are no less extensive and formidable than the *Teredo*. At Portpatrick it appears that both these animals have combined their forces in the work of destruction, the *Teredo* consuming the interior, and the *Limnoria* the superficial parts of the wood; the latter continuing its labours until it comes in contact with the shells of the former, so that the whole mass is speedily deprived of cohesion. It is stated, on the authorities of Mr. Hyndman and Mr. Stephen, that the *Limnoria* is already committing great ravages in the timber at Donaghadee.

2. "On the Nervous System of the *Sphinx ligustri* (Linn.) during the latter Stages of its Pupa and its Imago States; and on the Means by which its Development is effected." By George Newport, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

In a paper formerly read to the Royal Society, and printed in the Philosophical Transactions, the author has given a description of the anatomy of the nervous system of the *Sphinx ligustri* in its larva, and the earlier periods of its pupa, state; and he has since prosecuted the inquiry then commenced, following the changes of structure through the remaining stages, until the insect has arrived at its full development. He enters into minute details of all these changes, which vary considerably in the rapidity with which they take place at different periods, according as the vital powers are called into action by external circumstances, or become exhausted by their efforts at effecting the growth or modifying the form of different parts. Thus the ganglia and nervous cords undergo great changes both in their form and situation, and also in their number, during the passage of the insect from the larva to the pupa state; and after these changes have been carried to a certain extent, they are suspended for several weeks, during which the insect remains in a state of hybernation; but at the expiration of this period the changes again proceed, and are continued uninterruptedly, till the insect attains its ultimate or perfect stage of development. The *Sphinx ligustri* remains in the pupa state during at least forty-two or forty-three weeks; thus affording ample opportunities of examining the whole progress of the changes which take place in the structure of different parts. The concentration of the nervous system, which was commenced in the larva, proceeds to a much greater extent while the insect is inclosed in the pupa, and is continued for a short time after it has assumed the imago state. The double origin and connexions of the nerves distributed to the wings are described, and a conjecture offered as to the object of this arrangement, which appears designed to establish a harmony of action between the wings, in those insects, especially, which are remarkable for velocity and power of flight; a different disposition being adopted in those which fly with less regularity or speed. The nerves of the organs of sense, as the antennæ, eyes, proboscis, and apparatus for manducation, are traced and minutely described, and a comparison instituted between them and the nerves which have similar offices in vertebrated animals. The author traces the origin and course of the

nerve corresponding to the *pneumo-gastric*, or *par vagum*, and shows that it is distributed chiefly to the organs of digestion and the respiratory passages. He next describes the anterior lateral cephalic ganglia, which, from their position, might be regarded as auxiliary brains. The situation and course of another nervous tract, which from its extensive connexions and peculiar mode of distribution is considered as corresponding to the sympathetic system, are also traced. The author notices a set of nerves which, adopting the views of Sir Charles Bell, he considers as analogous to those which the latter has denominated the respiratory nerves of vertebrated animals; and among a great number of interesting observations, of which it is impossible to give any abridged account, one of the most remarkable is the discovery that the primary longitudinal nervous cords of insects consist of two tracts, the one situated over the other, corresponding to the two columns of which the spinal cord consists in vertebrated animals; the one appropriated to sensation, and the other to voluntary motion; the nerves from each of these tracts being variously combined, according to the purposes they are designed to fulfil. This important distinction, which was first traced in the nervous cords of the Lobster, was afterwards distinctly observed by him in the *Scorpion* and the *Scolopendra*, and lastly, in several species of insects, as the *Gryllus viridissimus*, the *Carabus*, the *Papilio urticae*, and the *Sphinx ligustri*. Numerous drawings of the parts described accompany the paper.

3. "Observations on the Torpedo, with an account of some additional experiments on its Electricity." By John Davy, M.D., F.R.S., Assistant Inspector of Army Hospitals.

The first part of this paper is occupied by an investigation of the circumstances attending the foetal development of the Torpedo. In the first stage of embryonic growth which the author had an opportunity of observing, when the embryo was about seven tenths of an inch in length, it had neither fins nor electrical organs, nor any appearance of eyes; it exhibited short external branchial filaments, not yet carrying red blood; and there was a red spot in the situation of the heart, communicating by red vessels in the umbilical cord with the vascular part of the egg. There is no membrane investing the foetus, as is the case with some species of *Squali*; nor any fluid in the uterine cavity; neither could the author find any urea or lithic acid in that cavity. By taking the mean of many observations, it appeared that the weight of the egg, before any appearance of the embryo, is 182 grs., and after its appearance, including the weight of the latter, 177 grs.; while the weight of the mature fish is about 479 grs.; showing an augmentation of more than double. Thus it differs remarkably, in this respect, from the foetal chick, which at its full time weighs considerably less than the original yolk and white from which it is formed. No communication can be traced between the foetus of the Torpedo and the parent, through the medium of any vascular or cellular structure; and the stomach of the former is always found empty. Hence the only apparent source of nourishment is absorption from the surface;

and the author states his reasons for believing that the branchial filaments are the principal absorbing organs, the materials they receive being chiefly employed in the construction of the electrical organs, while those which enter into the composition of the body generally are absorbed by the general surface of the foetus. The author is led, from his researches, to the conclusion that the mode of reproduction in the Torpedo is intermediate between the viviparous and the ovoviviparous.

In the second part of the paper, the author discusses the question as to the number of species of the genus *Torpedo* existing in the Mediterranean; and concludes that there are only two, viz. the *Ochiatella* and the *Tremola*.

4. "Appendix to a former Paper on Human Osteology." By Walter Adam, M.D. Communicated by Dr. Prout, F.R.S.

This appendix contains linear representations of various dimensions of the bones of the human body, both male and female, with a view to facilitate the comparison of the human frame with that of other animals, and reduce it to definite laws. The author states that many of the rectilinear dimensions of human bones appear to be multiples of one unit, namely, the breadth of the cranium directly over the external passage of the ear; a dimension which he has found to be the most invariable in the body. No division of that dimension was found by him to measure the other dimensions so accurately as that by seven, or its multiples. Of such seventh parts there appear to be twelve in the longitudinal extent of the back, and ninety-six in the height of the whole body.

5. "On the Repulsive Power of Heat." By the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

The expansion of bodies by heat appearing to imply a mutual repulsion of their particles, it becomes a question whether such repulsive power may not be excited by it between particles or masses of matter, at sensible as well as insensible distances. After noticing the partial investigations of this question by Libri, Fresnel, Saigey, and Professor Forbes, the author describes the methods he has employed with a view to its solution, and which consisted in applying heat to two lenses of glass, pressed together so as to exhibit the colours of thin plates; the variation of the tints furnishing exact indications of the most minute changes of distance between the surfaces, by whatever causes they may be produced. The conclusion he deduces from his experiments, conducted on this plan, is that the separation of the surfaces is of a different character, and is greater than can be accounted for by the mere change of figure produced by the heat; and is therefore in part to be ascribed to a real repulsive action between the surfaces of the glasses derived from the power of heat. He also found, on trying similar experiments with glass in contact with a metallic surface, that the results were considerably influenced by the radiating power of the latter, the effect being increased when this power was greater, and

also by all other causes tending to the more rapid communication of heat. This is still more apparent when the coloured rings are formed in a thin plate of water interposed between the lenses, and where the effects are independent of radiation.

6. "Analysis of the Moira Brine Spring near Ashby-de-la-Zouch, Leicestershire, with Researches on the Extraction of Bromine." By Andrew Ure, M.D., F.R.S.

The water derived from the spring in question is raised by means of a pump from the coal mines in the neighbourhood of Ashby-de-la-Zouch, is much used as medicinal baths, and is also administered internally, principally as a remedy for bronchocele and serofulous tumors. The result of the analysis made by the author, is that it contains per gallon,

Bromide of sodium and magnesium	grs. 8
Chloride of calcium	851.2
———— magnesium	16
———— sodium	3700.5
Protoxide of iron, a trace	

Solid contents 4575.7

After removing from the water the deliquescent chlorides of lime and magnesia by the addition of carbonate of soda, he transmits through the mother liquor, consisting of chloride and bromide of sodium, a current of chlorine gas, till it communicates the maximum golden tint, and then adds sulphuric æther, which, by agitation, carries with it to the surface the bromine and chlorine, constituting a reddish yellow stratum. The proportion in which these two elements exist in the evaporated solution may be ascertained with the greatest nicety by the addition of a solution of nitrate of silver; the method of calculation for this purpose being detailed by the author.

7. "On the Nature and Origin of the Aurorá Borealis." By the Rev. George Fisher, M.A., F.R.S.

The author deduces from his own observations made during a residence of two winters in high northern latitudes, taken in conjunction with the concurring testimony of various navigators and travellers, the general fact that the Aurora Borealis is developed chiefly at the edge of the Frozen Sea, or wherever there is a vast accumulation of ice; and he conceives that it is produced in situations where the vapours of a humid atmosphere are undergoing rapid congelation. Under these circumstances, when viewed from a distance, it is seen fringing the upper border of the dark clouds, termed the "sea blink," which collect over these places; and it generally forms an arch a few degrees above the horizon, shooting out vertical columns of pale yellow light. He concludes that the Aurora Borealis is an electrical phenomenon, arising from the positive electricity of the atmosphere, developed by the rapid condensation of the vapour in the act of freezing, and the induced negative electricity of the surrounding portions of the atmosphere; and that it is the immediate consequence

of the restoration of the electrical equilibrium by the intervention of the frozen particles, which being imperfect conductors, become luminous while transmitting this electricity. In tropical and temperate climates this phenomenon does not occur, because the electric equilibrium is restored by means of aqueous vapours, a process which often gives rise to thunder and lightning, but never to the Aurora Borealis; the latter being peculiar to clear, cold and dry weather.

8. "Théorie Balistique." Par M. Le Comte de Prédaval. Communicated by Dr. Roget, Sec. R.S.

The author inquires into the influence which he conceives the following circumstances may have on the path of a projectile on the surface of the earth; namely, first, the direction of the line of projection relatively to the meridian or cardinal points; secondly, the latitude of the place; and thirdly, the barometric conditions of the atmosphere.

9. "On the Atmospheric Tides and Meteorology of Dukhun, in the East Indies." By Lieut.-Colonel W. H. Sykes, F.R.S.

The author premises detailed descriptions of the various instruments used in the meteorological observations recorded in this paper, and of the methods employed in obtaining his results; of which the great features are the barometrical indications of diurnal and nocturnal atmospheric tides, embracing two maxima and two minima in the twenty-four hours. The following are the chief topics noticed in the paper, and the principal facts established by these inquiries: namely, 1. The removal of the doubts entertained by Humboldt, founded on the authority of Horsburgh, of the suspension of the atmospheric tides during the monsoon in Western India; the existence of the four atmospheric tides already mentioned, and their occurrence within the same limiting hours as in America and Europe; the greatest mean diurnal oscillations in Dukhun taking place in the coldest months, and the smallest in the damp months; whilst at Madras, the smallest oscillations are in the hottest months, and in Europe it is supposed that the smallest oscillations are in the coldest months. 2. The regular diurnal and nocturnal occurrence of the tides, without a single case of interversion, whatever may be the thermometric or hydrometric indications, or the state of the weather; storms and hurricanes only modifying, but not interrupting them. 3. The anomalous fact of the mean diurnal oscillations being greater at Poona, at an elevation of 1823 feet, than at the level of the sea, in a lower latitude, at Madras. 4. The fact of the diurnal tides, at a higher elevation than Poona, being less, whilst the nocturnal tides are greater than at Poona; and the seasons apparently not affecting the limiting hours of the tides. 5. The maximum mean pressure of the atmosphere being greatest in December and January; then gradually diminishing until July and August; and subsequently increasing to the coldest months. 6. The very trifling diurnal and annual oscillations compared with those of extra-tropical climates. 7. The annual range of the thermometer being less in Dukhun

than in Europe, but the diurnal range much greater; the maximum mean temperature occurring in April and May, and gradually declining until December and January; and the observed mean temperature of places on the continent of India being much higher than the calculated mean temperature according to Meyer's formula. 8. The mean annual dew-point being higher at half-past nine o'clock than either at sunrise or at four in the afternoon; the dew-point being highest during the monsoons, and lowest during the cold months, and varying considerably within very short distances; being, for example, remarkably contrasted in Bombay and Dukhun; and the frequent occurrence of dew quite locally and under anomalous circumstances. 9. The amount of rain in Dukhun being only 20 per cent. of that falling in Bombay, 90 or 100 miles to the westward. 10. The wind being principally from the west and east, and rarely from the opposite quarters. 11. The great abundance of electricity under certain circumstances. 12. The rare occurrence of fogs. 13. The great amount of solar radiation; and lastly, the singular opacity of the atmosphere during hot weather, giving rise occasionally to the mirage. A variety of tables containing the records of meteorological observations, with instruments, accompany the paper.

10. "On the Ova of the *Ornithorhynchus paradoxus*." By Richard Owen, Esq. Communicated by W. Clift, Esq., F.R.S.

The author, in this paper, has prosecuted more immediately and more minutely than in his former communication, the inquiry into the structure of the ovary of the *Ornithorhynchus*, with a view to determine its exact relations with that of the normal Mammalia, and of the oviparous Vertebrata. He has obtained from this investigation the full confirmation of the truth of the opinion he had previously formed, that lactation might coexist with a mode of generation essentially similar to that of the Viper and Salamander; and this fact has been further established by the subsequent examination which he has made of the uterine fœtus of the Kangaroo.

The author traces the regular gradation which obtains in different orders of Mammalia in which true viviparous or placental generation takes place, towards the ovo-viviparous or oviparous modes, in which the exterior covering of the ovum never becomes vascular, and shows that the *Ornithorhynchus* constitutes a connecting link in this chain.

Drawings illustrative of the anatomical descriptions of the parts examined by the author accompany the paper.

11. "Observations with the Horizontal and Dipping Needles, made during a Voyage from England to New South Wales." By James Dunlop, Esq. Communicated by Capt. Beaufort, R.N., F.R.S.

This paper contains a very numerous and uninterrupted series of magnetical observations, made in the circumstances stated in the title, and extending about 180 degrees in longitude and 100 degrees in latitude. The apparatus, of which a detailed description is given, was suspended from the roof of the cabin, and no alteration was made in its suspension from the beginning to the end of the voyage.

12 "Experiments on Light." By Henry Fox Talbot, Esq., M.P., F.R.S.

In the first section of this paper, an account is given of certain appearances presented by transparent objects, and especially saline crystals, viewed through a microscope, when illuminated by polarized light. For this purpose, the first polarizing medium, consisting of the arrangement of single-image calcareous spar, invented by Mr. Nichol, is fixed beneath the stage of the microscope; and the second, which is similar to it, is interposed between the eye-glass and the eye, and is capable of being turned on its axis, so as either to allow of the transmission of the whole of the light polarized by the first medium, or to intercept the whole of it, according as its position is similar, or at right angles to the former. In the latter case, any substance which has the property of depolarizing the light transmitted to it by the first medium, will appear luminous, while the rest of the field of view is quite dark, and will exhibit the most brilliant colours, dependent on its thickness and position; so that if the stage of the microscope be turned round, the colour of each crystal is seen to change, and gradually to assume the complementary tint. Other variations in the appearances are produced by interposing a plate of mica, which gives a general tint to the whole field of view, and modifies the colours of the objects viewed; and also by turning the polarizing eye-piece, so that the whole of the polarized light is transmitted; when crystals, which would be white if viewed by ordinary light, may be made to assume various colours, and even sometimes to appear perfectly opaque; a result which does not seem to be in accordance with that which theory would lead us to expect.

The second section is occupied with the development of a principle which the author conceives is extensively applicable to the purposes of photometry, or the accurate measurement of the intensity of light. It is founded on the well-known experiment of the appearance of a uniform grey tint presented by a circle, partly white and partly black, when made to revolve rapidly; the intensity of the light being regulated by the proportional spaces occupied by each colour. Several variations of this experiment are described, with a view to its practical application to the proposed object. The author also suggests the employment of methods founded on a similar principle to the measurement of quantities in various other branches of physical science; for example, that of high temperatures.

13. "On the Mummy Cloth of Egypt; with Observations on the Manufactures of the Ancients." By James Thomson, Esq., F.R.S. Communicated by Dr. Roget, Sec. R.S.

By subjecting the threads of various specimens of cloth, enveloping Egyptian mummies, to accurate microscopic examination, which was done at the request of the author by Mr. Bauer, it was ascertained that they were formed exclusively of the fibres of linen, and not of cotton, as had been supposed; a conclusion which is corroborated by other considerations stated by the author. The paper is accompanied by drawings, exhibiting the appearances of the threads both of cotton

and of linen, when highly magnified; and concludes with an historical disquisition on the cloth manufactures of the ancients, and the mention of experiments from which it is inferred that the principal colouring materials employed in dyeing the yarn were indigo and saffron.

14. "An Account of some Experiments to measure the Velocity of Electricity, and the Duration of Electric Light." By Charles Wheatstone, Esq., Professor of Experimental Philosophy in King's College, London. Communicated by Michael Faraday, Esq., F.R.S.

The continuance for a certain time of all luminous impressions on the retina prevents our accurately perceiving, by direct observation, the duration of the light which occasions these impressions, but by giving the luminous body a rapid motion, which produces the appearance of a continued train of light along the path it has described, its condition at each moment may be ascertained, and consequently its duration determined. The same law of our sensations precludes us from direct perception of the velocity with which the luminous cause is moving, as the whole of its track, for a certain distance, appears to be equally illuminated; but by combining a rapid transverse motion of the body from which the light proceeds, with that which it had before, its path may be lengthened to any assignable extent, and both its direction and its velocity will admit of measurement. The author gives various illustrations of this principle, and of his attempts to apply it to appreciate the duration and the velocity of the electric spark. His first experiments were made by revolving rapidly the electric apparatus giving electric sparks; but in every instance they appeared to be perfectly instantaneous. He next resorted to the more convenient plan of viewing the image of the spark reflected from a plane mirror, which, by means of a train of wheels, was kept in rapid rotation on a horizontal axis. The number of revolutions performed by the mirror was ascertained, by means of the sound of a siren connected with it, and still more successfully by that of an arm striking against a card, to be 800 in a second. The angular motion of the image being twice as great as that of the mirror, it was easy to compute the interval of time occupied by the light during its appearance in two successive points of its apparent path, when thus viewed; and it was ascertained that the image passed over half a degree (an angle which, being equal to about an inch, seen at a distance of ten feet, is easily detected by the eye,) in the 1,152,000th part of a second. The result of these experiments, as regarded the duration of the spark, was that it did not occupy even this minute portion of time; but when the electric discharge of a battery was made to pass through a copper wire of half a mile in length, interrupted both in the middle, and also at its two extremities, so as to present three sparks, they each gave a spectrum considerably elongated, and indicating a duration of the spark of the 24,000th part of a second. The sparks at both extremities of the circuit were perfectly simultaneous, both in their period of commencement and termination; but that which took place in the middle of the circuit, though of equal duration with the former, occurred later, by at least the millionth part

of a second, indicating a velocity of transmission from the former point to the latter of nearly 288,000 miles in a second; a velocity which exceeds that of light itself.

The following letter was read from the Chair.

“ British Museum, June 19th, 1834.

“ MY DEAR SIR,—His Royal Highness the President requests that, when you adjourn the meeting this evening to the 20th of November, you will have the goodness to express his great regret that, unfortunately, the state of his health and sight has lately been such as to render it impossible for him to preside at the ordinary meetings of the Society so frequently as it was his anxious wish to have done. His Royal Highness begs you will assure the Society that his absence has been occasioned by the cause alluded to alone, and from no feeling of diminished interest in the prosperity of the Royal Society, or of regard and respect for the Fellows; on the contrary, His Royal Highness hopes that, by the blessing of Providence, his health will soon be in all respects so far re-established as to enable him, on the reassembling of the Society, to resume the chair, and fill it with that uninterrupted regularity which it is His Royal Highness's most anxious wish to observe, in whatever duty he undertakes.

“ Ever, my dear Sir, faithfully yours,

“ JOHN GEORGE CHILDREN.

“ P.S.—His Royal Highness requests you will in his name bid the Fellows heartily farewell till he meets them again in November.”

“ Francis Baily, Esq., V.P. R.S.”

The Society then adjourned over the long vacation, to meet again on the 20th of November.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1834-1835.

No. 18.

November 20, 1834.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer,
in the Chair.

A paper was read, entitled, "On the Determination of the Terms in the disturbing Function of the fourth Order, as regards the Eccentricities and Inclinations which give rise to secular inequalities." By J. W. Lubbock, Esq., V.P. and Treas. R.S.

The author observes, that the magnitude of the terms of the fourth order in the disturbing function, relating to the inclinations, in the theory of the secular inequalities of the planets, does not admit of being estimated *à priori*; and consequently the amount of error which may arise from neglecting them cannot be appreciated. The object of the present investigation is to ascertain the analytical expressions of these terms; and the method adopted for this purpose is derived from principles already explained by the author in a former paper. He has bestowed great pains in putting these expressions into the simplest form of which they are susceptible; and has finally succeeded, after much labour of reduction, in obtaining expressions of remarkable simplicity. He exemplifies their application by the calculation, on this method, of one of the terms given by Professor Airy as requisite for the determination of the inequality of Venus; and arrives, by this shorter process, at the same result. The same method, he remarks, is, with certain modifications, applicable to the development of the disturbing function in terms of the true longitude.

A paper was also read, entitled "Note on the Astronomical Refractions." By James Ivory, Esq., K.H., M.A., F.R.S.

The object of this communication is to show how far the author has been successful in establishing the true theory of astronomical refractions, in his paper published in the Philosophical Transactions for 1823, by comparing the results of that theory with the best and most recent observations; namely, those recorded in the "*Fundamenta Astronomiæ*" of Bessel, and the "*Tabulæ Regiomontanæ*" of the same author. This comparison is made by taking the first and second differences of the series of the logarithms of the refractions in each table; from which it results that these differences, derived from the numbers in Bessel's tables, are very irregular; but that their mean very nearly coincides with that of the numbers given in the tables of the author.

November 27, 1834.

DAVIES GILBERT, Esq., M.A., V.P., in the Chair.

A paper was read, entitled, "Meteorological Journal kept at the Royal Observatory, Cape of Good Hope, from the 1st of February to the 31st of May, 1834." By Thomas Maclear, Esq. Communicated by Captain Beaufort, R.N., F.R.S.

The tables of meteorological observations which compose nearly the whole of this paper are preceded by a short notice of the instruments, namely, one barometer and two thermometers, with which the observations were made. The author announces his intention to forward, in a future communication, the results of a comparison between his barometer and that of Sir John Herschel. The observations are taken at sunrise, at noon, at sunset, and at midnight.

The reading of a paper was commenced, entitled, "On the Proofs of a gradual Rising of the Land in certain parts of Sweden." By Charles Lyell, Esq., F.R.S.

At the Anniversary Meeting, December 1, 1834, which was held on that day in consequence of St. Andrew's Day falling on a Sunday;

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer, in the Chair,

The Treasurer stated that he took the Chair on the present occasion in consequence of the unavoidable absence of His Royal Highness the President; from whom he had received the following letter:

"Dear Sir,

"May I request of you to express to the gentlemen assembled this day at the Royal Society Rooms, my extreme regret that the state of my eyesight should prevent my attending in my place on the present occasion, as it would otherwise have been both my duty and pleasure to have done? Under these circumstances I must rely upon that kindness which I have ever experienced at their hands since presiding over the interests of the Royal Society, to excuse this involuntary absence on my part. Should the gentlemen kindly vote me again into the Chair, aware as they are of my present infirmities, I can only accept the proffered honour upon an understanding that should I not be better at this period next year, I may be now considered as giving them notice that I shall consider myself bound in duty to resign an office, the duty of which I am no longer able to perform. I regret much being deprived of the pleasure of conferring the medals this day, and particularly the one which has been so properly adjudged to you, for whom I profess the highest consideration, and with which sentiment I subscribe myself,

"Very sincerely, yours, &c.,

(Signed) "AUGUSTUS FREDERICK, P.R.S.

"Kensington Palace, Dec. 1, 1834.

"John William Lubbock, Esq., Treasurer of the Royal Society."

Resolved unanimously,—That this Meeting deeply regrets the affliction which deprives the Society of His Royal Highness's attendance at the Anniversary Meeting, and confidently hope that his health will be speedily and completely restored.

The Rev. Mr. Peacock, as one of the Auditors on the part of the Society, reported that the balance in the Treasurer's hands at the present audit was £192 7s. 6½*d.* The thanks of the Society were voted to the Auditors for their trouble in auditing the Society's accounts.

The Secretary read the following List of Fellows deceased since the last Anniversary.

On the Home List.—Sir Gilbert Blane, Bart., M.D.; John, Marquis of Breadalbane; John Caley, Esq.; Rev. James Stanier Clarke, LL.D.; Captain James Franklin; William Wyndham, Lord Grenville; Philip, Earl of Hardwicke; George Harvey, Esq.; John Jebb, Lord Bishop of Limerick; Rev. Daniel Lysons; William Taylor Money, Esq.; John Sharpe, Esq.; Thomas Snodgrass, Esq.; William Sotheby, Esq.; George John, Earl Spencer; Thomas Telford, Esq.; Right Hon. Charles Philip Yorke.

On the Foreign List.—Don Felipe Bauzá and Professor Karl Ludwig Harding.

The Secretary stated that of these only two, namely, Sir Gilbert Blane and Mr. George Harvey, have contributed papers to the Royal Society.

Sir Gilbert Blane was the author of a paper, entitled, “An Account of the *Nardus Indica*, or Spikenard,” which was published in the Philosophical Transactions for 1790.

In this paper, Sir Gilbert, then Dr. Blane, establishes the identity of a species of grass, found in great abundance in a wild unfrequented part of India at the foot of the mountains north of Lucknow, and held in great estimation by the natives as a febrifuge, with the plant denominated by ancient writers the *Nardus Indica*, and which Arrian states was found in great quantity by the armies of Alexander during their marches through the deserts of Gadrosia, bordering on the Persian Gulf, and forming part of the modern province of Mekran. An account of the medicinal properties of this plant occupies the remainder of this paper.

In the year 1788, Sir Gilbert Blane was appointed to read the Croonian Lecture, in which he enters into a general account of the nature of the muscles and of the theory of muscular motion. This paper was not published in the Philosophical Transactions. The portion of it chiefly deserving notice is that which relates to the experiments made by him with a view to determine whether the specific gravity of a muscle is the same in its two states of relaxation and contraction. For this purpose he compared equal portions of the muscular flesh taken from the opposite sides of a fish, one of which had been contracted by crimping, and the other had remained relaxed; but he was unable to detect any sensible difference in their specific gravities. This conclusion was corroborated by the result of experiments on living eels, inclosed in vessels filled with water,

and terminating above in a tube of small diameter : the bulk of the fluid was observed to be unaffected by muscular contractions purposely excited in the fish, as appeared from the height of the column in the tube remaining unchanged during the most violent actions of the eels. In caoutchouc, on the other hand, Sir G. Blane found that extension produced a diminution, and retraction an increase, of density.

Mr. George Harvey was the author of a paper entitled " Experimental Inquiries relative to the Distribution and Changes of the Magnetic Intensity in Ships of War ;" and of another " On the Effects of the Density of Air on the Rates of Chronometers ;" both of which are published in the Philosophical Transactions for 1824. In the first paper he enters into a detail of experiments made on board several vessels for the purpose of determining the influence of the iron in the ships upon the mariner's compass in different situations and under different circumstances. In the second paper he ascertains that the rate of chronometers is accelerated by being placed in air of diminished density ; and that it was, on the contrary, retarded when they are subjected to increased atmospheric pressure ; the arc of vibration being, in the former case, increased ; and in the latter, diminished.

The Secretary then read the following Report :

The Council appointed by the Royal Society for the management of their affairs during the past year, conceiving, from the Report on the state of the finances presented by the Treasurer to the last Anniversary Meeting, that their earliest attention should be directed to this important subject, lost no time in nominating a Committee for taking it into consideration, and for devising the most eligible means of obviating the difficulties into which the Society might eventually be involved by the continuance of the present excess of their expenditure over their income. It appeared from that Report that the clear annual income of the Society, exclusive of payments made by new members, may be estimated at £1400 ; while the probable annual amount of ordinary expenses is £2000 ; leaving a deficiency, each year, of £600. By adopting a system of greater economy in the mode of arranging and printing the Transactions, and other measures of retrenchment, recommended by this Committee, the Council expect that in future this annual deficiency may be reduced to little more than £200. By an arrangement which they have made with the Editor of the weekly journal " The Athenæum," the expense of printing the Meteorological Tables, formerly appended to the Philosophical Transactions, and amounting to £26 annually, will be saved ; the Editor, in consideration of their being given to that journal exclusively, having agreed to deliver a thousand copies of those tables, printed in manner and form, and on paper, to correspond with the Transactions, every six months, to be bound up with the latter, free of all cost to the Society.

With a view to improve the permanent resources of the Society,

all the sums received on account of compositions for annual payments are in future to be invested in the funds. In the present year, however, this principle cannot be brought into operation; owing chiefly to the extraordinary expenses attending the arrangements necessary for the fitting up of the new rooms, and the cost of the new classed Catalogue. It has also been determined that, as the sum thus paid by each member as his composition is found, on an average, to bear a very inadequate proportion to the annual contributions for which it is substituted, this sum shall in future be raised from £40 to £60, to all those Fellows who have not contributed a paper to the Philosophical Transactions; while those who have presented to the Society a paper which has been printed in the Transactions, shall still be allowed the privilege of compounding for the smaller of these sums.

On the subject of the Library the Council have, in the first place, to report that the manuscript of the classed Catalogue is now very nearly completed, and that the printing of it will be very soon commenced.

The Council beg, in the second place, to congratulate the Society on their having, after so much delay, at length obtained possession of the apartments lately occupied as the Exchequer Office, and granted by the Lords Commissioners of His Majesty's Treasury, on the representation made to them by His Royal Highness our President, to the Royal, conjointly with the Astronomical, Society. The apartments retained by the Royal Society are four in number: the first is a room adjoining to the upper library, from which a door has been opened into it, and which has been fitted up with shelves for the reception of the books formerly kept in the rooms on the basement floor of the next house, under the rooms of the Geological Society. The second is a smaller room, communicating by a door with the Council-room. The third is also a small room, opening into the ante-room, on the same floor; and the Council have granted to Mr. Roberton the use of this room, together with coals and candles, and have required of him, in consideration of this favour, to engage to be in attendance, generally, from nine in the morning till five in the afternoon, and also at the evening meetings of the Society. The fourth room is situated on a lower floor.

It having been determined at a former Council, in November of last year, that application should be made to the Lords of the Admiralty to direct the observations made at various stations by their order, to be printed at the public expense; their Lordships have graciously acceded to this request.

The Council, having been applied to by the Commissioners of Excise to undertake the investigation of the proper instruments, and the construction of tables, for ascertaining the strength of spirits, with a view to the more accurate charging of the duty thereon, have appointed a Committee for conducting the proposed inquiry, and fulfilling the objects of the requisition.

The Copley Medal has been awarded by the Council to Professor Plana for his work, entitled "*Théorie du Mouvement de la Lune.*"

The two Royal Medals for the present year have been awarded; the one, on Physics, to John William Lubbock, Esq.; and the other, on Mineralogy and Geology, to Charles Lyell, Esq. The first is for Mr. Lubbock's highly valuable *Investigations on the Tides*, contained in his papers published in the *Philosophical Transactions*.

The second is awarded for Mr. Lyell's work, entitled "*Principles of Geology*," on the following grounds, the Council at the same time declining to express any opinion on the controverted positions contained in that work.

First, The comprehensive view which the author has taken of the subject, and the philosophical spirit and dignity with which he has treated it.

Secondly, The important service he has rendered to science by specially directing the attention of Geologists to effects produced by existing causes.

Thirdly, His admirable descriptions of many tertiary deposits; several of these descriptions being drawn from original observations.

And lastly, The new mode of investigating tertiary deposits, which his labours have greatly contributed to introduce; namely, that of determining the relative proportions of extinct and still existing species, with a view to discover the relative ages of distant and unconnected tertiary deposits.

The Council, being unable to propose any specific Prize-Question for the Royal Medal in Physics for the year 1837, propose to give one of the Royal Medals for that year to the most important unpublished paper in Physics, communicated to the Royal Society for insertion in their *Transactions*, after the present date and prior to the month of June 1837.

The Council propose to give the other Royal Medals for the year 1837 to the author of the best paper, to be entitled "*Contributions towards a system of Geological Chronology, founded on an examination of fossil remains, and their attendant phenomena.*"

The Treasurer made the following statements with respect to the Number of Fellows, the State of the Finances, and the Receipts and Payments of the Society during the preceding year.

At the last Anniversary, the Society consisted of 747 Members; of whom there were,

11 Royal Personages,
46 Foreign Members, and
690 Home Members.

Since that date, there have died,

17 on the Home List, and
2 on the Foreign List;

and there have been admitted,

40 on the Home List, (with
1 re-admission, and

1 restoration from the Deceased List,) and
0 on the Foreign List. Of whom

20 have compounded for life, and

20 have engaged to pay the Annual Subscription of 4*l*.

The Society therefore now consists of

11 Royal Personages,

44 Foreign Members, and

715 Home Members;

making a total of 770 Members; of whom

602 have compounded for life,

392 at the rate of 27*l*. 6*s*.

210 at the rate of 40*l*.

42 are subject to an annual payment of 2*l*. 12*s*.

71 are subject to an annual payment of 4*l*. 0*s*.

It appeared that the total Receipts for the then closed account, ending November 29, 1834, amounted to 3557*l*. 11*s*. 10*d*., and the total Disbursements to 3365*l*. 4*s*. 4½*d*.; so that there remained in the Treasurer's hands a balance of 192*l*. 7*s*. 5½*d*. according to the detailed statement printed for the use of the Fellows.

The Treasurer then laid before the Meeting the following

Statement of the Receipts and Payments of the Royal Society between Nov. 29, 1833, and Nov. 29, 1834.

1. RECEIPTS.

	£.	s.	d.
Balance in the hands of the Treasurer at the last Audit ..	543	9	2
Weekly Contributions, at one shilling	106	12	0
Quarterly Contributions, at £1	212	6	6
Forty Admission Fees	400	0	0
Twenty Compositions for Annual Payments	800	0	0
Rents:—	£.	s.	d.
One year's rent of estate at Mablethorpe: due at Michaelmas	107	0	0
One year's rent of premises in Coleman- street: due at Michaelmas	95	0	0
One year's rent of lands at Acton: due at Michaelmas	60	0	0
One year's fee-farm rent of lands in Sus- sex; land-tax deducted: due at Mi- chaelmas	19	4	0
One-fifth of the clear rent of an estate at Lambeth Hill, from the Royal College of Physicians, in pursuance of Lady Sadleir's will: due at Midsummer ..	3	0	0
	<hr/>	284	4 0
		<hr/>	2346 11 8

	£.	s.	d.	£.	s.	d.
Receipts.				2346	11	8
Brought forward.....						
Dividends on Stock :—						
One year's dividends on 14,000 <i>l.</i> Reduced						
Annuities	420	0	0			
<i>Pulteney Fund.</i>						
One year's dividends on 200 <i>l.</i> 3 per cent.						
Consols	6	0	0			
<i>Fairchild Fund.</i>						
One year's dividends on 100 <i>l.</i> New South						
Sea Stock	3	0	0			
<i>Rumford Fund.</i>						
One year's dividends on 2161 <i>l.</i> 0 <i>s.</i> 10 <i>d.</i>						
3 per cent. Consols.....	64	16	8			
<i>Donation Fund.</i>						
One year's dividends on 3820 <i>l.</i> 19 <i>s.</i> 3 <i>d.</i>						
3 per cent. Consols	114	12	6			
				608	9	2
Miscellaneous Receipts :—						
Sale of Philosophical Transactions	534	10	3			
Sale of Abstracts of Papers.....	67	11	9			
Sale of Sir H. Davy's Discourses.....	0	9	0			
				602	11	0
Total.....	£3557	11	10			

2. PAYMENTS.

	£.	s.	d.
<i>Lady Sadleir's Legacy.</i> —The Poor of the Parish, in pursuance of Lady Sadleir's Will.....	3	0	0
<i>Fairchild Lecture.</i> —The Rev. J. J. Ellis, for delivering the Fairchild Lecture of 1834	3	0	0
<i>Donation Fund.</i> —Professor Schumacher, in re-payment for one of Buzengeiger's best Barometers; with additional Tubes and Mercury.....	48	5	2
—Mr. Newman, on account, for Standard Barometer	32	7	0
<i>Royal Medals.</i> —Mr. Wyon: for engraving names.....	5	0	0
Salaries :—			
Dr. Roget, one year, as Secretary	105	0	0
J. G. Children, Esq., one year, as Secretary	105	0	0
Ditto for Index to Phil. Trans.	5	5	0
C. König, Esq., one year as Foreign Secretary	20	0	0
Carried forward.....	235	5	0
	91	12	2

	£.	s.	d.	£.	s.	d.
Salaries :—						
Brought forward.....	235	5	0	91	12	2
Mr. Hudson, one year, as Assistant-Secretary	250	0	0			
Mr. Robertson, one year, as assistant to ditto	100	0	0			
Mr. Gould, one year, as Porter	60	0	0			
				645	5	0
Mr. Robertson : For assisting Mr. Panizzi : One year				54	12	0
Mrs. Coppard : Gratuity.....				10	0	0
Fire Insurance, on the Society's Property				22	11	6

Bills :—

Taylor :

Printing the Phil. Trans., 1833, part 2 .	368	16	2
Printing the Phil. Trans., 1834, part 1 .	154	11	0
Printing and Paper of Proceedings, Nos. 13, 14, 15, 16, and 2nd Title .	51	3	6
Miscellaneous Printing: Circulars, Lists of Fellows, Ballot-lists, Statement of Payments, President's Addresses, Minutes of Council, and for Advertisements	123	16	9

Bowles and Gardiner :

Paper for the Phil. Trans., 1833, part 2 .	49	0	0
Paper for the Phil. Trans., 1834, part 1 .	79	16	0
Paper for the Phil. Trans., 1834, part 2 .	144	4	0

Basire :

Engraving and Copper-plate printing for the Phil. Trans., 1833, part 2 .	70	18	0
Engraving and Copper-plate printing for the Phil. Trans., 1834, part 1 ..	7	12	6
Engraving and Copper-plate printing for the Phil. Trans. 1834, part 2 ..	364	0	10
Engraving and Copper-plate printing of Circulars, Diplomas, and Plates to 'complete sets	15	19	5

Vizetelly and Branston :

Wood Engravings for Phil. Trans. 1833, part 2	21	5	0
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Gyde :

Sewing 1780 Parts of Phil. Trans. ..	59	6	8
Boarding 20 Parts of ditto, gilt	2	0	0
Boarding 50 Sets of Abstracts, 2 vols. 8vo.....	3	6	8
Sewing and covering Proceedings, Parts I. and II.—III. 704 copies..	5	5	6

1521 2 0

Carried forward.....

2345 2 8

	£.	s.	d.	£.	s.	d.
Bills:—						
Brought forward.....				2345	2	8
Few & Co., Solicitors	6	3	10			
Tuckett:						
Bookbinding: 216 vols. (189, quartos)	53	8	6			
Chappell:						
Stationery	16	19	6			
Saunderson:						
Shipping expenses	19	8	1			
Arnold and Johnson, Coal-merchants.	42	0	0			
Brecknell and Turner:						
Wax Lights, Candles, and Lamp Oil	58	17	0			
Skelton:						
Cleaning Chandeliers; Fenders; and repairing Lamps and Locks	10	4	5			
Cubitt:						
Builder's work in New Rooms	417	3	0			
Pryer and Spice:						
Upright and Sloped Desks.....	3	12	0			
Cleaning Marble Busts, Mantel-pieces and Picture Frames	4	18	0			
Travelling Packing Cases for Phil. Trans. &c.	9	6	6			
Carpet-beating, Table for Library Tea, Bed-hire, and Carpenter's work ..	19	10	6			
Snell:						
Picture Rods in Meeting Room	14	12	0			
Cobbett and Son:						
Window-cleaning and Glazing	7	3	1			
Guillim:						
Soap, large Mats, Brushes, Fire-wood, &c.....	22	1	10			
				705	8	3
Books bought on account of the Money received from the British Museum:						
Bailliére: Books,—on account	113	5	0			
Simpkin and Marshall: Ditto	6	19	2			
Rich: Ditto	1	5	6			
Humboldt's <i>Vues des Cordillères</i>	5	17	0			
				127	6	8
Parish Rates and Petty Charges:						
Taxes and Parish Rates	46	11	7			
Troughton and Simms: Setting off the new Barometer Scale	1	11	6			
Cary: Repairing Thermometer	0	6	6			
Molyneux: Repairing and cleaning Journeyman-clock	1	8	0			
L'Institut Journal	3	1	3			
Carried forward.....	£ 52	18	10	3177	17	7

	£.	s.	d.	£.	s.	d.
Bills :—						
Brought forward	52	18	10	3177	17	7
Postage and Carriage	28	6	9			
Extra Porterage, and delivery of 900 Circulars	20	10	10½			
Expenses on Foreign Packets and Pre- sents	7	13	6			
Stamps	3	9	0			
Men removing Books in Library	9	3	4			
Charwoman's Wages	12	12	0			
Extra charwoman's work	3	9	9			
Board and Wages of Servant	30	0	0			
Miscellaneous expenses	19	2	9			
				187	6	9½
				£	3365	4 4½
Balance in the hands of the Treasurer				192	7	5½
				£	3557	11 10

December 1st, 1834.

J. W. LUBBOCK, *Treasurer*.

The thanks of the Society were voted to the Treasurer for his able services in attending to its finances.

The statutes relating to the election of Council and Officers were then read by the Secretary; and Joseph Smith, Esq., and William Spence, Esq., being nominated by the President, with the approbation of the Meeting, Scrutators to assist the Secretaries in examining the balloting-lists, the votes of the Fellows present were collected.

Joseph Smith, Esq., having reported, on the part of the Scrutators, the result of the ballot, the following gentlemen were declared duly elected as composing the Council and Officers for the ensuing year; namely,

President: His Royal Highness the Duke of Sussex, K.G.—*Treasurer*: John William Lubbock, Esq., M.A.—*Secretaries*: Peter Mark Roget, M.D.; John George Children, Esq.—*Foreign Secretary*: Charles König, Esq.

Other Members of the Council: Charles Frederick Barnwell, Esq.; Henry Thomas De la Beche, Esq.; William Thomas Brande, Esq.; Sir Benjamin Collins Brodie, Bart.; Michael Faraday, Esq.; Henry Holland, M.D.; Rev. Philip Jennings, D.D.; Charles Lyell, jun., Esq.; Herbert Mayo, Esq.; Roderick Impey Murchison, Esq.; Lord Oxmantown; Rev. George Peacock; Rev. Baden Powell; Sir John Rennie; Edward Turner, M.D.; Rev. William Whewell.

The thanks of the Society were then voted to the Scrutators for their trouble in assisting at the election.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1834-1835.

No. 19.

December 18, 1834.

SIR BENJAMIN COLLINS BRODIE, Bart., Vice-President, in the Chair.

The Rev. John Barlow, M.A.; Rev. James William Bellamy, B.D.; William Brockedon, Esq.; Thomas Galloway, Esq., M.A.; Bisset Hawkins, M.D.; Col. Andrew Leith Hay, K.H., M.P.; Francis Kiernan, Esq.; George Lowe, Esq.; Richard Owen, Esq.; Benjamin Phillips, Esq.; Richard Saumarez, Esq.; Charles John Kemys Tynte, Esq., M.P.; and John Gardner Williamson, Esq.; were elected Fellows of the Society.

The reading of a paper, entitled, "On the Proofs of a gradual Rising of the Land in certain parts of Sweden." By Charles Lyell, Esq., F.R.S., was resumed, but not concluded.

January 8, 1835.

The REV. PHILIP JENNINGS, D.D., Vice-President, in the Chair.

On the Proofs of a gradual Rising of the Land in certain parts of Sweden. By Charles Lyell, Esq., F.R.S.

An opinion has long been entertained that the waters of the Baltic and even of the whole Northern Ocean, have been gradually sinking; and the purport of the present paper is, to communicate the observations which the author made during the summer of 1834, in reference to this curious question. In his way to Sweden he examined the eastern shores of the Danish islands of Moën and Seeland, but neither there, nor in Scania, could he discover any indications of a recent rising of the land; nor was there any tradition giving support to such a supposition. The first place he visited, where any elevation of land had been suspected, was Calmar; the fortress of which, built in the year 1030, appeared, on examination, to have had its foundations originally laid below the level of the sea, although they are now situated nearly two feet above the present level of the Baltic. Part of the moat on one side of the castle, which is believed to have been formerly filled with water from the sea, is now dry, and the bottom covered with green turf. At Stockholm, the author found many striking geological proofs of a change in the relative level of the sea and land, since the period when the Baltic has been inhabited by the

Testacea which it now contains. A great abundance of shells of the same species were met with in strata of loam, &c., at various heights, from 30 to 90 feet above the level of the Baltic. They consist chiefly of the *Cardium edule*, the *Tellina baltica*, and the *Littorina littoreus*; together with portions of the *Mytilus edulis*, generally decomposed, but often recognisable by the violet colour which they have imparted to the whole mass. In cutting a canal from Sodertelje to lake Maelar, several buried vessels were found; some apparently of great antiquity, from the circumstance of their containing no iron, the planks being fixed together by wooden nails. In another place, an anchor was dug up; as also, in one spot, some iron nails. The remains of a square wooden house were also discovered at the bottom of an excavation made for the canal, nearly at a level with the sea, but at a depth of 64 feet from the surface of the ground. An irregular ring of stones was found on the floor of this hut, having the appearance of a rude fire-place, and within it was a heap of charcoal and charred wood. On the outside of the ring was a heap of unburnt fir wood, broken up as for fuel; the dried needles of the fir and the bark of the branches being still preserved. The whole building was enveloped in fine sand.

The author next notices several circumstances regarding buildings in Stockholm and its suburbs, from which he infers that the elevation of the land, during the last three or four centuries, has not exceeded certain narrow limits. At Upsala he met with the usual indications of a former elevation of the sea, from the presence of littoral shells of the same species as those now found in the Baltic. Certain plants, as the *Glaucia maritima* and the *Triglochin maritimus*, which naturally inhabit salt marshes bordering the sea, flourish in a meadow to the south of Upsala; a fact which corroborates the supposition that the whole of the lake Maelar and the adjoining low lands have, at no very remote period of history, been covered with salt water.

The author examined minutely certain marks which had at different times been cut artificially in perpendicular rocks, washed by the sea, in various places; particularly near Oregrund, Gefle, Löfgrund, and Edskösund; all of which concur in showing that the level of the sea, when compared with the land, has very sensibly sunk. A similar conclusion was deduced from the observations made by the author on the opposite, or western coast of Sweden, between Uddevalla and Göteneburg; and especially from the indications presented by the islands of Orust, Gulholmen, and Marstrand.

Throughout the paper a circumstantial account is given of the geological structure and physical features of those parts of the country which the author visited: and the general result of the comparison he draws of both the eastern and western coasts and their islands, with the interior, is highly favourable to the hypothesis of a gradual rise of the land; every tract having, in its turn, been first a shoal in the sea, and then, for a time, a portion of the shore. This opinion is strongly corroborated by the testimony of the inhabitants, (pilots and fishermen more especially,) of the increased extension of the land, and the apparent sinking of the sea. The rate of elevation, however,

appears to be very different in different places : no trace of such a change is found in the South of Scania. In those places where its amount was ascertained with greatest accuracy, it appears to be about three feet in a century. The phenomenon in question having excited increasing interest among the philosophers of Sweden, and having especially excited the attention of Professor Berzelius, it is to be hoped that the means of accurate determination will be greatly multiplied.

January 15, 1835.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer, in the Chair.

Second Essay on a general Method in Dynamics. By William Rowan Hamilton, Esq., Andrew's Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland. Communicated by Captain Beaufort, R.N., F.R.S.

This essay is a sequel of the one which appeared in the last volume of the Philosophical Transactions, and which contained a general method for reducing all the most important problems of dynamics to the study of one characteristic function, or one central or radical relation. It was there remarked that many eliminations required by this method might be avoided by a general transformation, introducing the time explicitly into a part (S) of the whole characteristic function (V); and the first object of the present essay is to examine and develop the properties of this part (S), which the author designates by the term *Principal Function*. This function is applied by the author to problems of perturbation, in which he finds it dispenses with many laborious and circuitous processes, and furnishes accurate expressions of the disturbed configurations of a system by the rules of undisturbed motion, if only the initial components of velocities be changed in a suitable manner. Another manner of extending rigorously to disturbed, the rules of undisturbed motion, by the gradual variation of elements, in number double the number of the coordinates or other marks of position of the system, which was first invented by Lagrange, and was afterwards improved by Poisson, is considered in this second essay under a form rather more general; and the general method of calculation which has already been applied by the author to other analogous questions in optics and in dynamics, is now applied to the integration of the equations which determine these elements. This general method is founded chiefly on a combination of the principle of variations with those of partial differentials, and may furnish, when matured, a separate branch of analysis, which may be denominated the *Calculus of Principal Functions*. When applied to the integration of the equations of varying elements, it suggests the consideration of a certain *Function of Elements*, capable of being variously transformed, and which may be either rigorously determined, or at least approached to, by a corollary of the general method. With a view to illustrate these new principles, and more especially those connected

with problems of perturbation, they are applied, in this essay, first, to a very simple example, suggested by the motions of projectiles, the parabolic path being treated as the undisturbed; and secondly, to the problem of determining the motions of a ternary or multiple system, with any laws of attraction or repulsion, and with one predominant mass. This latter problem, which was touched upon in the former essay, is here resumed in a new manner, by forming and integrating the differential equations of a new set of varying elements, entirely distinct in theory (though little differing in practice) from the elements conceived by Lagrange; and having this advantage, that the differentials of all the new elements for both the disturbed and disturbing masses may be expressed by the coefficients of one disturbing function.

An Account of the Eruption of Mount Etna in the year 1536, from an original cotemporary document, communicated in a letter to J. G. Children, Esq., Secretary of the Royal Society. By Sir Francis Palgrave, K.G.H., F.R.S.

Record Office of the Treasury, Chapter House,
Poets' Corner, Westminster, Jan. 14, 1835.

Amongst various shreds and fragments of the correspondence from Italy during the period that Henry VIII. was negotiating with the Italian princes, is a document of a very different nature from the rest, being an extract from a letter written by the Barone di Burgis, dated at Palermo, 10th of April 1536, and giving an account of the then recent eruption of Mount Etna.

"Die xxij. Martii, M. D. xxxvi., nocte, Mons Ethna qui nunc Mongibellus vocatur; facto, orientem versus, ostio, emisit materiam igneam, quæ ad instar fluminis vagata est per octo miliaria in longitudine, et per unum miliare in latitudine; ejus vero altitudo erat palmarum duodecim. Eâdem nocte ignis extinctus est, et ubique remansit nigra materies prædictæ altitudinis duodecim palmarum. Ignis totam liquefecit nivem, quæ ad instar rapidi torrentis tanto impetu defluit, ut domus, arbores, et quicquid obviam esset secum traheret.

"Sequentibus autem diebus scissa sunt alia ostia numero tredecim, quæ miro strepitu ignem evomebant ad instar bombardarum; longèque ab his per unum miliare cadebant ingentia saxa, quorum aliquot judicata sunt ponderis ultra quindecim cantanorum. Post strepitum sequebatur odor sulphureus per aliquot miliaria in locis circumvicinis. Tantus erat impetus hujus igneæ materiei, ut arbores prostraret et evellet antequam eas tangerat, sique veterem materiem incendiorum præteritorum sæculorum, offendebat, eam denuo incendebat.

"Ex quolibet ostio profuebant amplissimi rivi, qui aliquo in loco suâ latitudine unum miliare occupabant, erantque altitudine duodecim palmarum.

"Duravit hic ignis per sex dies, et singulâ quâque nocte aspiciebatur in cacumine montis, ignis; die vero, fumus.

"Sed cognosci nequibat quem faceret effectum, quia illuc ascendere non licebat propter relictam materiem incendii."

On the Electrical Relations of Metals and Metalliferous Minerals, By R. W. Fox, Esq. Communicated in a letter to Davies Gilbert, Esq., F.R.S.

The author states that he has ascertained that the crystallized gray oxide of manganese holds a much higher place in the electro-magnetic scale than any other body with which he has compared it, when immersed in various diluted acids, and alkaline solutions : he also gives a table of the order in which other metals and minerals stand in this respect. When employed in voltaic combinations he found that on being so arranged as to act in opposition to one another, the direction of the resultant of their action, as indicated by the deflection of the magnetic needle, did not coincide with the mean of the directions of the needle when under the separate influence of each. Hence he infers that the needle is not a true index of the electricity transmitted; and that electro-magnetic action does not depend on a continuous electric current. He conceives, therefore, that the phenomena are better explained on the hypothesis of pulsations which he formerly advanced. A galvanometer of a new construction is employed by the author for weighing the deflecting force of these electrical impulses.

On the Circulation of the Blood in Insects. By John Tyrrell, Esq., A.M. Communicated by P. M. Roget, M.D., Secretary to the Royal Society.

The observations on the circulation of the blood in insects, which is a discovery of comparatively recent date, have been made almost exclusively on insects in the larva state ; but the author of the present paper details a variety of observations of the same fact in insects which had arrived at their last or perfect stage of development. Among the *Myriapoda*, the circulation was traced in the *Geophilus*, and still more distinctly in the *Lithobius forficatus*. The author also detected the circulation, by the motion of globules, through the nervures of the wings of various perfect insects, namely, of some species of the *Hemerobius*, *Panorpa*, *Phryganea*, and *Ephemera*; and particularly in the *Musca domestica*, or common house-fly. The paper is accompanied by drawings of the appearances described.

January 22, 1835.

JOHN WILLIAM LUBBOCK, Esq., Vice-President and Treasurer, in the Chair.

A paper was read, entitled, "Notes on the Temperature of the Air and the Sea, &c., made in a Voyage from England to India, in the Ship Hoogly, Capt. Reeves, in the year 1833." By Alexander Burnes, Esq., F.R.S.

The observations contained in this communication are recorded in a tabular form, and show that the variations of the temperature of the sea accord very closely with those of the air, in all the latitudes which the author traversed in this voyage.

A paper was then read, entitled, "Remarks on certain Statements of Mr. Faraday, contained in the Fourth and Fifth Series of his Experimental Researches in Electricity." By John Davy, M.D., F.R.S.

Dr. Davy complains that Mr. Faraday has, in the paper referred to, made certain statements with respect to the opinions of Sir Humphry Davy relative to the conducting powers of dry nitre, and caustic potash and soda, when in fusion by heat, and also with regard to other matters connected with voltaic electricity, which are not correct; and vindicates Sir Humphry Davy from the charge of want of perspicuity in the statement of his views of these subjects.

A Note by Mr. Faraday on the preceding Remarks by Dr. Davy was then read, in which he replies to the charges there brought forward, and justifies those statements, the accuracy of which had been impugned by Dr. Davy.

January 29, 1835.

WILLIAM THOMAS BRANDE, Esq., V.P. in the Chair.

The reading of a paper was commenced, entitled, "Experimental Researches in Electricity. Ninth Series." By Michael Faraday, Esq., D.C.L., F.R.S.

February 5, 1835.

The Rev. PHILIP JENNINGS, D.D., Vice-President, in the Chair.

Albert William Beetham, Esq.; John Edye, Esq.; John Hamett, M.D.; John Greathed Harris, Esq.; the Rev. Henry Tattam, M.A.; and Martin Tupper, Esq.; were elected Fellows of the Society.

Mr. Faraday's paper, entitled, "Experimental Researches in Electricity. Ninth Series," was resumed and concluded.

In the series of experiments which are detailed in this paper, the author inquires into the causes of some remarkable phenomena relating to the action of an electric current upon itself, under certain circumstances, whereby its intensity is highly exalted, and occasionally increased to ten, twenty, or even fifty times that which it originally possessed. For the production of this effect, the principal condition is that the current traverse a considerable length of a good conductor, such as a long wire; more especially if this wire be coiled in the form of a helix; and the effect is still farther augmented when this helix is coiled round a cylinder of soft iron, constituting an electro-magnet. The evidence on which these conclusions are founded is the following. If an electromotor, consisting of a single pair of zinc and copper plates, have these metals connected by a short wire dipping into cups of mercury, the electric spark consequent upon either forming or breaking the circuit is so slight as to be scarcely perceptible; but if a long wire be employed as the medium of connexion, a bright spark is obtained on breaking the contact. If the wire be coiled in a helix,

the spark is still brighter ; and if a core of soft iron be placed within the helix, the spark, at the moment of disjunction, is more brilliant than in any of the former cases : and the higher intensity of the current is also manifested by the occurrence of a shock, at the same moment, to a person who grasps with wetted hands the two ends of the wire ; whereas no such effect, nor even any sensible impression on the tongue, is produced by the electromotor, when a short wire is employed.

All these effects of exaltation are produced at a time when the actual current of electricity from the electromotor is greatly diminished ; as the author shows by many experiments on the ignition of a fine wire, and the deflection of a galvanometer. He also proves that the effects of the spark and the shock, at the moment of disjunction of a long wire, are due to a current far more powerful than that which passes through the short wire at the same instant ; or indeed than that which passes through either the long or the short wire at any other instant of time than when the disjunction takes place.

That this extraordinary effect is not due to any species of inertia, is shown by the fact, that the same wire will produce it in a greater or less degree, under circumstances incapable of influencing any effect depending on inertia : thus, if 100 feet of wire, when extended, produce a certain effect, a greater effect will be produced by coiling the same wire into a helix, and a still more powerful one by employing it as the helix of an electro-magnet.

The author ultimately refers these phenomena to an inductive action of the current, analogous, or perhaps identical, with that described in the First Series of these Experimental Researches : for he found that when a second wire was placed parallel to the long conducting wire, the ends of this second wire being connected together so that a current of electricity could circulate round it, then the spark and shock did not take place at the first wire at the moment of disjunction, but a current was induced at the second wire, according to the law originally described in the First Series. The moment the current in the second wire was interrupted, the spark and shock appeared at the first. These and many other experiments were adduced to prove that these effects, namely, the shock and the spark, result from an inductive action of the original current, producing, at the moment it is stopped, a current, in the same direction as itself, in the same wire which serves to convey the original current.

The author, lastly, considers the reverse effect produced upon making contact ; and concludes his paper by some general views of the consequences resulting from this inductive action in various cases of electric discharge ; pointing out the important influence it must have in magneto-electrical machines of the ordinary construction.

The reading of a paper was then commenced, entitled, " Geometrical Researches concerning Terrestrial Magnetism." By Thomas Stephens Davies, Esq., F.R.S., &c.

February 12, 1835.

WILLIAM THOMAS BRANDE, Esq., Vice-President, in the Chair.

Mr. Davies's paper, entitled "Geometrical Researches concerning Terrestrial Magnetism," was resumed and concluded.

The object of this paper is to exhibit methods of conducting the mathematical inquiries which are applicable to the magnetism of the earth, by the aid of the coordinate geometry of three dimensions.

When a point on the surface of the earth is given by means of its geographical coordinates, we can also refer it to any rectilinear coordinates that may be found convenient, and the transformations of the expressions can be made by known and familiar methods. Also, since at a given point the needle is deflected a measured quantity from the meridian plane, estimated on a tangent plane to the earth at the given point, and is also depressed another measured quantity below the same plane at that given point, its position is fixed by means of these measures. It will hence become capable of reference also to the same rectilinear coordinates as those into which the geographical coordinates were transformed. The equation of the line, into which the dipping-needle disposes itself, becomes, therefore, capable of expression in terms of the measured quantities above referred to; viz., the latitude, longitude, dip, and variation. The method of obtaining the constants which enter into the "equations of the needle" as referred to the equator, a given meridian, and the meridian at right angles to it, are then detailed at length by the author; and these equations are calculated for six different places: Port Bowen, Boat Island, Chamisso Island, Valparaiso, Paris, and Paramatta.

With a view to bring the hypothesis of the duality of the centres of magnetic force to a test, the author proceeds to reason, that as a free needle subjected to the action of only two poles, will always dispose itself in the plane which passes through those poles and the centre of motion of the needle, the needle prolonged will always intersect the magnetic axis, or line which passes through the two poles. But when four straight lines are given in space, a fifth line (or rather two lines) can be so drawn as to intersect them all. If, therefore, we have the equations of four dipping-needles calculated from correct observations, we ought to be able to assign the equations of the two lines which rest upon them; one or other of which, in such case, will be the magnetic axis itself. This line ought to intersect every other needle; and hence the constants in its equations and the constants in the equations of any fifth needle ought to fulfill the algebraical test of intersection. The author has calculated the equations of the magnetic axis for the needles at Chamisso, Valparaiso, Paramatta, and Port Bowen, and made a comparison of it with the Paris needle. Instead of intersecting, the least distance between the said axis and needle is more than one 6th of the terrestrial radius; and hence, could the observations themselves be depended on, as being free from instrumental error and from local disturbances, the question of the duality of the centres of force would be at once settled in the negative; but, as the opinions of those philo-

sophers who are best acquainted with the dipping-needle are decidedly that the dipping-needle is not yet in such a condition as to induce implicit confidence in its indications, and as, moreover, the influence of geological and meteorological sources of disturbance are yet so far unappreciated as to enable us to correct the observations for them, the author hesitates to draw any positive conclusion from the results he has obtained. However, the results thus obtained, being the direct and legitimate deductive consequences of the observations, it is of course impossible by any other course of investigations which proceeds from the same data, to draw a conclusion more to be depended on than this. The process he considers to be mathematically correct, as well as complete, and practicable; the question, as far as this test is concerned, must remain open till satisfactory data can be obtained: and he proposes at the earliest period to resume the numerical discussion of such observations as he may be able to procure.

Mr. Davies remarks, that from the great labour of the calculations, he has been led to attempt a more brief method of examination by means of carefully executed geometrical constructions; employing for that purpose the descriptive geometry, which has the advantage of bringing all the work to depend on the intersection of the hyperbola and straight line, situated upon the same plane. The resulting magnetic axes of the few cases he has constructed, though very far from coinciding, are yet positive in the same general region of the figure; and therefore the probability that their want of coincidence arises from erroneous and uncorrected observation is increased, and the importance of a more extended and careful series of observations considerably augmented.

For the purpose of examining the general character of the magnetical phenomena which ought to result from the hypothesis of the duality of the poles, Mr. Davies proceeds to investigate the formulæ which express those phenomena. These are, the magnetic equator,—the points at which the needle should become vertical,—the lines of equal dip,—the Halleyan lines, or lines of equal variation,—the isodynamic lines of Hansten,—and the points at which the magnetic intensity, compared with the points immediately contiguous in all directions, is a maximum, or in other words, where the isodynamic lines are reduced to points. The first two of these only, are treated in the present paper; the remaining ones will be the subject of a future memoir shortly to be submitted to the Society.

The mathematical processes themselves scarcely admit of verbal description; but the results of the investigation are briefly these.

When the centres of force are situated within the sphere, there will be one only, or some even number of continuous lines on the surface of the earth, at any point of which the needle will be horizontal, according as the poles be of equal or unequal intensities. Whether the magnetic equator be determined with sufficient accuracy to assure us that there is but one such line, is a matter of considerable doubt; but if it should be admitted that it is, it offers a strong confirmation of the strict analogy between the terrestrial and all other magnets with

two poles, and thence an increasing confidence in all the other analogies conceived to exist between them.

The points at which the needle is vertical are given by means of two equations, one of the fifth and the other of the second degree, and hence altogether there are ten such points theoretically possible. How many of these may be simultaneously real the equations do not, in their literal form, seem capable of determining; but at all events they will, in all cases, be an even number, either 0, 2, 4, 6, 8, or 10. One having been determined, one other at least must exist in the actual circumstances of the terrestrial two-poled magnet. How many so-ever such simultaneous points there may be, they must all lie in the same plane; and hence, if the second point which must exist could be determined, then the great circle in the plane of which the axis of the magnet itself is situated would be determined; and thus another test would be afforded of the truth or error of the hypothesis itself. Mr. Davies suggests that as this plane will be symmetrical with respect to the phenomena taking place on each side of it, its position might be tentatively assigned from a series of observations of those phenomena, especially of the dip and intensity; the variation being for obvious geometrical reasons excluded.

Though the resulting formula does not, in its literal form, appear to be capable of decomposition into factors, yet from some considerations, chiefly analogical, Mr. Davies is led to hazard the conjecture that it is capable of such decomposition; but as this is uncertain, he builds no consequences upon it, but leaves those consequences which would flow from it, open till it shall be discovered whether they would be justified by the conjecture itself being proved to be correct.

A paper was also read, entitled, "On certain Peculiarities in the double Refraction, and Absorption of Light, exhibited in the Oxalate of Chromium and Potash." By Sir David Brewster, K.H., L.L.D., F.R.S.

The crystals of the oxalate of chromium and potash are, generally speaking, opaque; for at thicknesses not much greater than the 25th of an inch, they are absolutely impervious to the sun's rays, and their colour, seen by reflected light, is nearly black; but when powdered, they are green; and the colour of the smaller crystals, viewed either by reflected or by transmitted daylight, is blue. One of the most remarkable of the properties of this salt is the difference of colour in the two images formed by double refraction. At a certain small thickness, the least refracted image is bright blue, and the most refracted image bright green. The blue is found by analysis with the prism to contain an admixture of green, and the green an admixture of red; and by candlelight this red predominating over the green, gives the crystal a pink hue. At greater thicknesses the blue becomes purer and fainter, and the green passes into red; and at a certain thickness the least refracted blue image disappears altogether, and the most refracted image is alone seen. At still greater thicknesses this image also disappears, and absolute opacity ensues. When the crystal is exposed to polarized light, with its axis in the plane of polarization,

the transmitted light is green ; but when the axis is perpendicular to that plane, the transmitted light is blue. A solution of the salt exhibits the same general action upon light as the solid, with the exception of double refraction. This salt has also the peculiar property of exciting a specific action upon a definite red ray, situated near the extremity of the red portion of the spectrum.

February 19, 1835.

Sir JOHN RENNIE, Knt. Vice-President, in the Chair.

A paper was read, entitled, "On the probable Position of the South Magnetic Pole." By Edward Rudge, Esq., F.R.S., &c.

The recent discovery of the site of the North Magnetic Pole, which has resulted from the experiments of Capt. James Ross, suggested to the author the inquiry whether any similar indications of an approach to the South Magnetic Pole can be gathered from any observations now on record. With this view a table is given of the observations made by Tasman in 1642 and 1643, during his voyage of discovery in the Southern Ocean, extracted from his journal; from which it appears that he on one occasion noticed the continual agitation of the horizontal needle, in south latitude $42^{\circ} 25'$, and longitude from Paris 160° . On the presumption that the South Magnetic Pole was at that time near this spot, and that it has since been retrograding towards the East, the author conjectures that it will now be found in or about the 43rd parallel of south latitude; and to the south-east of the Island of Madagascar, a situation extremely convenient for ascertaining its exact position, which he considers as an object of great theoretical as well as practical importance.

The reading of a paper was then commenced, entitled, "An Experimental Inquiry into the Cause of the grave and acute Tones of the Human Voice." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

February 26, 1835.

JOHN WILLIAM LUBBOCK, Esq., Vice-President and Treasurer, in the Chair.

The reading of a paper, entitled, "An Experimental Inquiry into the Cause of the grave and acute Tones of the Human Voice." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Secretary to the Royal Society, was resumed and concluded.

The author considers all the theories hitherto proposed respecting the functions of the organs of the human voice, as not only unsatisfactory, but as being founded on erroneous views. He shows that the modulation of the tones of the voice is not the result of variations

either exclusively in the length or in the tension of the vocal chords, or in the size of the aperture of the glottis, or in the velocity or the temperature imparted to the air in its transit through these passages. He regards the organs of the voice as combining the properties of wind and of stringed musical instruments ; and shows, first, that for the production of any musical tone it is necessary that the vocal chords should previously be made mutually to approximate ; and, secondly, that the muscular forces acting on the arytenoid cartilages and vocal chords are adequate not only to resist the pressure of the column of air issuing from the lungs, but also to render either the whole or certain portions of the vocal chords susceptible of vibration when traversed by the current of respired air. In proportion as these parts of the vocal chords, thus rendered vibratory, increase in length, the number of their vibrations, performed in a given time, diminishes, and the tone of the sound emitted becomes, in consequence, more grave ; and, conversely, the tone is more acute as the vibrating portions of the chord are shorter : these phænomena being precisely analogous to those which take place in stringed musical instruments.

The author concludes his paper with some observations on the comparative physiology of the voice ; and on the extensive range and superior excellence of this faculty in man.

The following letter was read ;

British Museum, February 26th, 1835.

MY DEAR SIR,

I am commanded by His Royal Highness the President of the Royal Society to request that you will state from the Chair, at the close of this evening's meeting, how sincerely His Royal Highness regrets that, in consequence of the opinion of Dr. Maton and his other medical advisers, he is obliged, *for the present*, to forego the pleasure, so truly gratifying to himself, of holding the usual Soirées at Kensington Palace. His Royal Highness, however, hopes that, by the blessing of Providence, he may yet have the satisfaction of receiving the Fellows as heretofore, before the termination of the present Session.

I am ever, my dear Sir, faithfully yours,

JOHN GEORGE CHILDREN, Sec. R. S.

John William Lubbock, Esq.

V. P. and Treas. R. S.

March 5, 1835.

Sir BENJAMIN COLLINS BRODIE, Bart., Vice-President, in the Chair.

A paper was read, entitled, " A new Method of discovering the Equations of Caustics." By G. H. S. Johnson, M.A., Tutor of Queen's College, Oxford. Communicated by the Rev. Baden Powell, M.A., F.R.S.

Peculiar difficulty has hitherto attended the determination of the

equation of the curve formed by the perpetual intersection of rays, which, diverging from a luminous point, are reflected by a polished surface of a given curvature. Curves of this description have been denominated caustics; and the method usually employed to discover their polar equations, or the relation between the radius vector of any point of the curve and the tangent at that point, is both long and inelegant, and is considered by the author as involving considerable inaccuracy of reasoning. He proposes, therefore, to substitute a new method of investigation, by taking the polar equation of one of the reflected rays, and differentiating this equation with respect to the arbitrary quantities solely which determine its position, and thus obtaining the polar co-ordinates of the point of intersection of two consecutive lines; and finally, by elimination, the equation of the curve in which all such points are found. He is thus led to results remarkable for their simplicity, elegance, and generality: and he gives particular applications of his method, exemplifying the facility with which it effects the solution of problems extremely difficult of management by the ordinary methods hitherto employed. His method is also applicable to the determination of the equations of the evolutes of curves, and to various other problems of a similar nature.

A paper was also read, entitled, "Discovery of the Metamorphoses in the second Type of the Cirripedes, viz. the *Lepadæ*, completing the Natural History of these singular Animals, and confirming their affinity with the Crustacea." By J. V. Thompson, Esq., F.L.S., Deputy Inspector General of Hospitals. Communicated by Sir James Macgrigor, Bart., M.D., F.R.S.

The discoveries made by the author of the remarkable metamorphoses which the animals composing the first family of the Cirripedes, or *Balani*, undergo in the progress of their developement, and which he has published in the third number of his *Zoological Researches* (p. 76), are in the present paper, which is intended as a prize Essay for one of the Royal Medals, followed up by the report of his discovery of similar changes exhibited by three species of two other genera of the second tribe of this family, namely, the *Lepadæ*. The larvæ of this tribe, like those of the *Balani*, have the external appearance of bivalve *Monoculi*, furnished with locomotive organs, in the form of three pairs of members, the most anterior of which are simple and the other bifid. The back of the animal is covered by an ample shield, terminating anteriorly in two extended horns, and posteriorly in a single elongated spinous process. Thus they possess considerable powers of locomotion, which, with the assistance of an organ of vision, enable them to seek their future permanent place of residence. The author is led from his researches to the conclusion that the Cirripedes do not constitute, as modern naturalists have considered them, a distinct class of animals, but that they occupy a place intermediate between the Crustacea decapoda, with which the *Balani* have a marked affinity, and the Crustacea entomostraca, to which the *Lepadæ* are allied; and that they have no natural affinity with the Testaceous Mollusca, as was supposed by Linnæus, and all the older systematic writers on Zoology.

March 12, 1835.

The Rev. PHILIP JENNINGS, D.D., Vice-President, in the Chair.

Continuation of a former paper "On the twenty-five feet Zenith Telescope, lately erected at the Royal Observatory;" by John Pond, Esq., F.R.S., Astronomer Royal.

For determining the place of any star passing the meridian near the zenith, at the Royal Observatory at Greenwich, three different methods may be employed: first, by means of the mural circles; secondly, by the zenith telescope, used alternately east and west; and lastly, by means of a small subsidiary angle, as described by the author in a former paper. The details of computations made according to each of these three methods are contained in the present paper; from which it appears that they all give results nearly identical; and that, when the observations with the two circles are made with sufficient care, the greatest error to be apprehended does not exceed the quarter of a second.

"Remarks towards establishing a Theory of the Dispersion of Light." By the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

In an abstract of M. Cauchy's Theory of Undulations, published in the London and Edinburgh Journal of Science, the author of the present paper deduced a formula expressing precisely the relation between the length of a wave and the velocity of its propagation; and showed that this last quantity is, in fact, the same as the reciprocal of the refractive index. The author here examines, by means of this formula, the relation between the index of refraction and the length of the period, or wave, for each definite ray, throughout the whole series of numerical results which we at present possess; and the conclusion to which he arrives from this comparison, for all the substances examined by Fraunhofer, viz. for four kinds of flint glass, three of crown glass, water, solution of potash, and oil of turpentine, is that the refractive indices observed for each of the seven definite rays are related to the length of waves of the same rays, as nearly as possible according to the formula above deduced from Cauchy's theory. For all the media as yet accurately examined, therefore, the theory of undulations, as modified by that distinguished analyst, supplies at once both the law and the explanation of the phenomena of the dispersion of light.

March 19, 1835.

Sir JOHN RENNIE, Knt., Vice-President, in the Chair.

A paper was read, entitled, "Some Account of the Eruption of Vesuvius, which occurred in the month of August, 1834, extracted from the manuscript notes of the Cavaliere Monticelli, Foreign Associate of the Geological Society, and from other sources; together with a Statement of the Products of the Eruption, and of the Con-

dition of the Volcano subsequently to it." By Charles Daubeny, F.R.S., F.G.S., and Professor of Chemistry in the University of Oxford.

It appears, from the information collected by the author, that for a considerable time previously to the late eruption of Vesuvius, stones and scorïæ had been thrown up from the crater, and had accumulated into two conical masses, the largest of which was more than two hundred feet in height. On the night of the 24th of August last, after the flow of considerable currents of lava, a violent concussion took place, followed by the disappearance of both these conical hillocks, which, in the course of a single night, were apparently swallowed up within the cavities of the mountain. Fresh currents of lava continued to flow for several days subsequently, destroying about 180 houses, spreading devastation over a large tract of country, and destroying all the fish in the neighbouring ponds and lakes. After the 29th of August, no further signs of internal commotion were manifested, with the exception of the disengagement of aqueous and æriform vapours from the crater, a phenomenon which, in a greater or less degree, is at all times observable. The author descended twice into the interior of the crater, which then presented a comparatively level surface; its sides consisting of strata of loose volcanic sand and rapilli, coated with saline incrustations of common salt, coloured red and yellow by peroxide of iron. The vapours which issued from various parts of the surface, collected and condensed by means of an alembic, introduced into the ground, were found to consist principally of steam and muriatic acid, with only a slight trace of sulphureous or sulphuric acids. From a trial with solution of barytes, the author concludes that carbonic acid was also exhaled, but neither nitrogen nor sulphuretted hydrogen appeared to form any part of the gas emitted. The steam issuing from the lava contained both free muriatic acid and also muriate of ammonia, which latter salt could not be detected in the gas from the volcano itself. The author conceives that these volatile principles are entangled in the lava, and are subsequently disengaged.

March 26, 1835.

WILLIAM THOMAS BRANDE, Esq., Vice-President, in the Chair.

"On the Temperature of some Fishes of the Genus *Thunnus*." By John Davy, M.D., F.R.S., Assistant Inspector of Army Hospitals.

The author had occasion to observe, many years ago, that the Bonito (*Thynnus pelamys*, Cuv.) had a temperature of 99° of Fahr. when the surrounding medium was 80°·5, and that it, therefore, constituted an exception to the generally received rule that fishes are universally cold-blooded. Having found that the gills of the common Thunny of the Mediterranean (*Thynnus vulgaris*, Cuv.) were supplied with nerves of unusual magnitude, that the heart of this latter fish was very powerful, and that its muscles were of a dark red colour, he was led to conjecture that it might, like the Bonito, be also warm-blooded; and this opinion is corroborated by the testimony of several intelligent fisher-

men. The author endeavours to extend this analogy to other species of the same family, which, according to the reports of the fishermen of whom he made inquiries, have a high temperature, and in whose internal structure he noticed similar peculiarities as in the Thunny; namely, very large branchial nerves, furnished with ganglia of considerable size. In this respect he considers that in these fishes the branchial system of organs makes an approximation to the respiratory apparatus of the Mammalia, and that it probably contributes to the elevation of temperature, resulting from the more energetic respiration which he supposes to be exercised by these organs. He, however, thinks it not improbable that these fish may possess means of generating heat peculiar to themselves, and of which at present we have no adequate idea. He conceives that the situation of the kidneys, of which a considerable portion is even higher than the stomach, and posterior to the gills, and which are of large size, and well supplied with nerves and blood-vessels, may possibly act a part in the production of an elevated temperature; but, on the whole, he is disposed to ascribe the greatest share of this effect to the superior magnitude of the branchial nerves.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1834-1835.

No. 20.

April 2, 1835.

JOHN WILLIAM LUBBOCK, Esq., M.A., V.P. and Treasurer, in
the Chair.

James Burnes, M.D.; Joseph Delafield, Esq.; G.W. Featherstonhaugh, Esq.; James Alexander Gordon, M.D.; Colonel Sir Robert John Harvey; Thomas Leybourn, Esq.; George Moore, Esq.; Arthur Morgan, Esq.; Charles Henry Oakes, Esq., B.A.; John Henry Pelly, Esq.; Richard Taunton, M.D.; William Tite, Esq.; Samuel Warren, Esq.; James Wigram, Esq., M.A.; and Charles J. B. Williams, M.D.; were elected Fellows of the Society.

A paper was read, entitled, "On the Results of Tide Observations, made in June 1834, at the Coast-Guard Stations in Great Britain and Ireland." By the Rev. W. Whewell, F.R.S., Fellow of Trinity College, Cambridge.

On a representation made by the author of the advantages which would result from a series of simultaneous observations of the tides, continued for a fortnight, along a great extent of coast, orders were given for carrying this measure into effect at all the stations of the Preventive service on the coasts of England, Scotland, and Ireland, from the 7th to the 22nd of June inclusive. From an examination of the registers of these observations, which were transmitted to the Admiralty, but part of which only have as yet been reduced, the author has been enabled to deduce many important inferences. He finds, in the first place, that the tides in question are not affected by any general irregularity, having its origin in a distant source, but only by such causes as are merely local, and that therefore the tides admit of exact determination, with the aid of local meteorological corrections. The curves expressing the times of high water, with relation to those of the moon's transit, present a very satisfactory agreement with theory; the ordinates having, for a space corresponding to a fortnight, a minimum and maximum magnitude, though not symmetrical in their curvatures on the two sides of these extreme magnitudes. The amount of flexure is not the same at different places; thus confirming the result already obtained by the comparison of previous observations, and especially those made at Brest; and demonstrating the futility of all attempts to deduce the mass of the moon from the phenomena of the tides, or to correct the tables of the tides by means of the mass of the moon. By the introduction of a local, in addition to the general, semimenstrual inequality, we may succeed in recon-

ciling the discrepancies of the curve which represents this inequality for different places; discrepancies which have hitherto been a source of much perplexity. These differences in the semimenstrual inequality are shown by the author to be consequences of peculiar local circumstances, such as the particular form of the coast, the distance which the tide wave has travelled over, and the meeting of tides proceeding in different directions; and he traces the influence of each of these several causes in producing these differences. A diurnal difference in the height of the tides manifests itself with remarkable constancy along a large portion of the coast under consideration. The tide hour appears to vary rapidly in rounding the main promontories of the coast, and very slowly in passing along the shores of the intervening bays; so that the cotidal lines are brought close together in the former cases, and, in the latter, run along nearly parallel to the shore; circumstances which will also account for comparative differences of level, and of corresponding velocities in the tide stream. The author intends to prosecute the subject when the whole of the returns of these observations shall have undergone reduction.

A paper was also read, entitled, "Copies of Registers of the Thermometer kept at Alford, Aberdeenshire." By the Rev. James Farquharson, F.R.S.

The observations recorded in these tables were made at 9^h 15^m A.M., and at 8^h 30^m P.M., each day of the year 1833; and the highest and lowest temperatures in each month observed from the indications of Six's thermometer. The author remarks that the differences between the temperature of the morning and evening hours of observation were greatest, on an average, during clear weather; that is, when the radiation of heat from the ground is greatest.

The reading of another paper, by the same author, entitled "On the Ice, formed under peculiar circumstances, at the bottom of running Water," was commenced, but not concluded.

SIR BENJAMIN COLLINS BRODIE, Bart., Vice-President, in the Chair.

The reading of a paper entitled, "On the Ice, formed under peculiar circumstances, at the bottom of running Water." By the Rev. James Farquharson, of Alford, F.R.S., was resumed and concluded.

The ice, which is frequently observed to collect at the bottom of streams and rivers, differs in appearance from that which is formed at the surface; for, instead of assuming the shape of solid glass-like plates, it has more the appearance of aggregated masses of snow, and is composed of small crystals of ice adhering together irregularly, either by their sides or angles. Rivers are sometimes so choked up by accumulations of ground-ice of this description, that they are not only impeded in their course, but also raised considerably above their banks. While in this state, a slight change in the weather will frequently occasion the complete disengagement of this ice from the bottom; so that, in a very short space of time, the river returns into its natural channel;

and then, although it may be frozen at the surface, it continues to flow over a perfectly clear bottom. All these phenomena are considered by the author as perfectly explicable on the theory he advances, of different degrees of radiation of heat occurring from the bottom according to variations of circumstances. He conceives that when this radiation takes place from the solid opaque materials of the bed of the stream, through the stratum of transparent water, congelation is induced on that portion of fluid, already cooled down to the freezing-point, which is in immediate contact with the radiating body. The circumstances which, by favouring radiation, contribute to this effect, are, principally, great clearness of the sky, and great transparency of the water; the bottom of the river being cooled below the freezing-point sooner than the water which is flowing over it; and the ice, formed at the bottom, remaining attached to it, as long as the heat which is transmitted from below continues to be lost by radiation. The formation of ground-ice is favoured by the intestine motions incident to a rapid current; because the different strata of fluid, which in still water would have arranged themselves, according to their specific gravities, in the order most conducive to the congelation of the surface, being continually mixed together, the whole body of water is cooled more uniformly.

The Society then adjourned over the Easter recess to meet again on the 30th instant.

April 30, 1835.

The REV. PHILIP JENNINGS, D.D., Vice-President, in the Chair.

A paper was read, entitled, "Continuation of the paper on the relations between the Nerves of Motion and of Sensation, and the Brain; and more particularly on the structure of the Medulla Oblongata and of the Spinal Marrow." By Sir Charles Bell, F.R.S.

The author enters into a minute anatomical investigation of the structure of the spinal cord, and of its relations with the encephalon, and with the origins of the nerves. He finds that the spinal cord is constituted, in its whole length, by six pairs of columns, namely, two posterior, two lateral, and two anterior; each column being composed of concentric layers, and invested with an external coating of cineritious substance, and all the columns being divided from each other by deep sulci, which penetrate nearly to the centre of the cord. On tracing the posterior columns in their ascent towards the encephalon, they are seen to diverge laterally at the *calamus scriptorius*, or bottom of the fourth ventricle, and to proceed into the substance of the cerebellum. Each of these posterior columns is here found to consist of two portions, the outermost being the largest; and they now constitute the *processus cerebelli ad medullam oblongatam*. This subdivision of the posterior columns may be traced throughout the whole length of the spinal cord. The lateral columns give origin to the posterior roots of the spinal nerves, and are therefore the parts subservient to sensation. In ascending towards the brain, each of these co-

lumns has a double termination ; first, in the root of the fifth pair of cephalic nerves ; and secondly, in the place where both columns unite into one round cord, and mutually decussate.

Between the lateral and the anterior columns there is interposed a layer of cineritious matter, constituting a continuous stratum from the *cauda equina* to the roots of the auditory nerves. There is also a septum, dividing the right and left tracts subservient to sensation in the region of the fourth ventricle, and apparently terminating at the point of decussation of these tracts ; but, in reality, separating to allow of this decussation, and joining the central portion of the cord, which connects the posterior with the anterior columns, and extends from the *pons Varolii* to the *cauda equina*.

The anterior columns, constituting, at their upper part, the *corpora pyramidalia*, after their union and decussation, compose the motor columns of the spinal cord. They do not, in their course, unite or decussate with the lateral, or sensitive columns ; decussation taking place only among the columns performing similar functions ; that is, the motor columns with the motor, and the sensitive with the sensitive.

May 7, 1835.

Sir JOHN RENNIE, Knt., Vice-President, in the Chair.

The first paper read was entitled, "On the Elements of the Orbit of the Comet of Halley in 1759." By J. W. Lubbock, Esq., V.P. and Treasurer of the Royal Society.

In calculating the elements of Halley's comet, former astronomers have in general adopted the parabolic hypothesis, neglecting the reciprocal of the semi-axis major ; and even in the more recent investigations of its orbit, no accurate value of this quantity has been employed. Mr. Lubbock, perceiving the serious effect which an error in the semi-axis major would occasion in the determination of the other elements, renewed these very laborious calculations, assuming as the value of this quantity that given by M. Pontécoulant, in his "*Théorie analytique du Système du Monde*;" taking also into account the alterations which the elements of the comet have undergone by the action of the planets, and likewise the effect of precession upon the longitude of the node, and of the perihelion. The author takes this opportunity of correcting the very erroneous statements that have been made respecting the results of his investigations, especially with regard to the time of the perihelion passage, which is, of course, very different from that of its actual appearance to spectators on the earth ; although these two epochs are frequently confounded with one another.

The second was entitled, "Formulæ for computing the Longitude at Sea;" by William Dunlop, Esq. Communicated by the Secretaries.

These formulæ, in which the longitude and latitude of two points in a spherical surface, together with the arc of the great circle intercepted between them, are supposed to be given, furnish the means

of determining the longitude of any other point in that circle, from its latitude.

The third paper was entitled, "Hygrometrical Observations made on board His Majesty's surveying vessel *Ætna*." Communicated by Captain Beaufort, R.N., F.R.S.

These observations extend from the 27th of March to the 6th of July, 1834, and were made daily at 8 o'clock A.M., at noon, and at 4 o'clock P.M. They comprise the height of the barometer, the dew-point, degrees of dryness on the thermometrical, and of moisture on the hygrometrical scales, the elasticity of the vapour, and the number of grains of vapour in a cubic foot; with occasional remarks. A second series is also given, exhibiting the progress of solar radiation.

The fourth was a "Meteorological Register, from the 1st of January to the 1st of November, 1834," by Mr. Edward Barnett. Communicated by Capt. Beaufort, R.N., F.R.S.

These observations, made during a voyage across the Atlantic, relate chiefly to the temperatures of the air, and of the surface of the sea.

The fifth was a "Meteorological Register, kept on board His Majesty's Ship *Thunder*, between the 1st of January and the 30th of June, 1834," by R. Owen, Commander. Communicated by Captain Beaufort, R.N., F.R.S.

These observations relate to the state of the weather, the direction and force of the wind, and the heights of the thermometer, and of the marine and oil barometers.

May 14, 1835.

JOHN WILLIAM LUBBOCK, Esq., Vice-President and Treasurer, in the Chair.

A paper was read, entitled, "An Account of the Water of the Well *Zem-zem*, with a qualitative analysis of the same by Professor Faraday"; in a letter from John Davidson, Esq., to the Secretaries, and communicated by them.

The author having, during his stay at Jedda, the port of Mecca, succeeded in procuring about three quarts of the water from the well of *Zem-zem*, to which the Mahomedans ascribe a sacred character and extraordinary virtues; and wishing to preserve this water for the purposes of analysis, had the can in which it was contained carefully sealed; but, unfortunately, on its arrival in the London Docks, the can, notwithstanding the directions written on it, was opened, and the gas with which it was highly charged, and by which it held in solution a very large quantity of iron and other matters, was allowed to escape. The precipitate thrown down, in consequence of the loss of this gas, was found, by Professor Faraday, to consist of carbonate of protoxide of iron in the enormous proportion of 100·8 grains to the imperial pint of water. The clear fluid was neutral, and contained much muriate, and a little sulphate, but no carbonate; together with a little lime, potash, and soda. There was also found an alkaline ni-

trate in considerable quantity ; this Mr. Faraday conjectures to have been saltpetre, which had been added to the water by the priests.

The reading of a paper was commenced, entitled, " Observations on the Theory of Respiration." By William Stevens, M.D., D.C.L., Fellow of the Royal College of Physicians of Copenhagen, and of Surgeons of London. Communicated by W. T. Brande, Esq., V.P.R.S.

May 21, 1835.

WILLIAM THOMAS BRANDE, Esq., Vice-President, in the Chair.

The reading of the paper, entitled, " Observations on the Theory of Respiration." By William Stevens, M.D. D.C.L., Fellow of the Royal College of Physicians of Copenhagen, and of Surgeons of London. Communicated by W. T. Brande, Esq., V.P.R.S., was resumed and concluded.

From the fact that no carbonic acid gas is given out by venous blood when that fluid is subjected to the action of the air-pump, former experimentalists had inferred that this blood contains no carbonic acid. The author of the present paper contends that this is an erroneous inference ; first, by showing that serum, which had been made to absorb a considerable quantity of this gas, does not yield it upon the removal of the atmospheric pressure ; and next, by adducing several experiments in proof of the strong attraction exerted on carbonic acid both by hydrogen and by oxygen gases, which were found to absorb it readily through the medium of moistened membrane. By means of a peculiar apparatus, consisting of a double-necked bottle, to which a set of bent tubes were adapted, he ascertained that venous blood, agitated with pure hydrogen gas, and allowed to remain for an hour in contact with it, imparts to that gas a considerable quantity of carbonic acid. The same result had, indeed, been obtained, in a former experiment, by the simple application of heat to venous blood confined under hydrogen gas ; but on account of the possible chemical agency of heat, the inference drawn from that experiment is less conclusive than from experiments in which the air-pump alone is employed. The author found that, in like manner, atmospheric air, by remaining, for a sufficient time, in contact with venous blood, on the application of the air-pump, acquires carbonic acid. The hypothesis that the carbon of the blood attracts the oxygen of the air into the fluid, and there combines with it, and that the carbonic acid thus formed is afterwards exhaled, appears to be inconsistent with the fact that all acids, and carbonic acid more especially, impart to the blood a black colour ; whereas the immediate effect of exposing venous blood to atmospheric air, or to oxygen gas, is a change of colour from a dark to a bright scarlet, implying its conversion from the venous to the arterial character : hence the author infers that the acid is not formed during the experiment in question, but already exists in the venous blood, and is extracted from it by the atmospheric air. Similar experiments made

with oxygen gas, in place of atmospheric air, were attended with the like results, but in a more striking degree ; and tend therefore to corroborate the views entertained by the author of the theory of respiration. According to these views, it is neither in the lungs, nor generally in the course of the circulation, but only during its passage through the capillary system of vessels, that the blood undergoes the change from arterial to venous ; a change consisting in the formation of carbonic acid, by the addition of particles of carbon derived from the solid textures of the body, and which had combined with the oxygen supplied by the arterial blood : and it is by this combination that heat is evolved, as well as a dark colour imparted to the blood. The author ascribes, however, the bright red colour of arterial blood, not to the action of oxygen, which is of itself completely inert as a colouring agent, but to that of the saline ingredients naturally contained in healthy blood. On arriving at the lungs, the first change induced on the blood is effected by the oxygen of the atmospheric air, and consists in the removal of the carbonic acid, which had been the source of the dark colour of the venous blood ; and the second consists in the attraction by the blood of a portion of oxygen, which it absorbs from the air, and which takes the place of the carbonic acid. The peculiar texture of the lungs, and the elevation of temperature in warm-blooded animals, concur in promoting the rapid production of these changes.

May 28, 1835.

Sir BENJAMIN COLLINS BRODIE, Bart., Vice-President, in the Chair.

A paper was in part read, entitled, " On the Influence of the Tricuspid Valve of the Heart on the Circulation of the Blood." By Thomas Wilkinson King, Esq., M.R.C.S. Communicated by Thomas Bell, Esq., F.R.S.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1834-1835.

No. 21.

June 4, 1835.

The Rev. GEORGE PEACOCK, M.A., Vice-President, in the Chair.

Edward Blackett Beaumont, Esq.; William Borrer, Esq.; John Davidson, Esq.; Sir Richard Dobson, Knt.; Thomas Jones, Esq.; Thomas Mayo, M.D.; Benjamin Oliveira, Esq.; and Captain William Symonds, R.N., were elected Fellows of the Society.

M. Elie de Beaumont; M. Frederick Cuvier; M. Flourens; Professor Hanson; and Dr. Rosenberger, were elected Foreign Members of the Society.

The reading of a paper, entitled, "On the Influence of the Tricuspid Valve of the Heart on the Circulation of the Blood." By T. W. King, Esq., M.R.C.S. Communicated by Thomas Bell, Esq., F.R.S.,—was resumed and concluded.

The purport of this paper is to prove experimentally that the tricuspid valve of the human heart does not, in the ordinary state of the circulation, completely prevent the reflux of blood from the ventricle into the auricle on the right side, and that the amount of regurgitation is continually varying according to the different degrees of distention of the ventricle. The author points out the anatomical differences between the auriculo-ventricular valves on the right and left sides of the heart; from the consideration of which it might have been inferred, independently of direct experiment, that while the structure of the mitral valve is adapted to close accurately all communication between the left auricle and ventricle during the contraction of the latter, that of the tricuspid valve is designedly calculated to allow, when closed, of the flow of a certain quantity of blood from the right ventricle back again into the auricle. The comparatively imperfect valvular function of these latter membranes is shown by various experiments on recent hearts, in which it was found that fluids injected, through the aorta, into the left ventricle, were perfectly retained in that cavity, by the closing of the mitral valve; but that when the right ventricle was similarly injected through the pulmonary artery, the tricuspid valves generally allowed of the escape of the fluid in streams, more or less copious, in consequence of the incomplete apposition of their margins. On repeating these experiments on different animals the author obtained similar results; but found that the imperfection of the valvu-

lar function was greater, the sooner the heart was examined after the death of the animal ; and that if the trials were made after the lapse of a certain time, the rigidity which gradually supervened on the muscular fibres of the heart, and of the *carneæ columnæ* attached to the margins of the valves, brought them into more complete apposition and led to the accurate closing of the passage. This effect, however, was never so perfectly accomplished in the tricuspid, as in the mitral valves.

The author regards this peculiarity of structure in the tricuspid valve as an express provision against the mischiefs that might result from an excessive afflux of blood to the lungs, analogous to a safety-valve ; and as more especially advantageous in incipient diseased enlargements of the right ventricle. He adverts to the conditions of the heart during the foetal state of existence, in which the same necessity of guarding against excessive pressure does not occur, and where the structures are found to correspond to the variation of functions. A similar adjustment of the right auriculo-ventricular valve to the peculiar circumstances and habits of animals may also be traced by extending the inquiry to various classes of animals.

“ Report of a Committee for collecting Information respecting the occurrence of, and the more remarkable Phænomena connected with, the Earthquakes lately felt in the Neighbourhood of Chichester.” By J. P. Gruggen, Esq. Communicated in a letter to P. M. Roget, M.D., Sec. R.S.

This paper contains an authentic report of the shocks of earthquakes which, during the last two years, have been felt at Chichester and the surrounding country ; drawn up from accounts given by various correspondents, in answer to printed queries extensively circulated. The first shock occurred on the 18th of September, and the second on the 13th of November, 1833. Another and more severe shock was felt on the 23d of January, 1834, and in the latter end of the same year two slighter shocks were experienced, namely, one on the 27th of August, and the next on the 21st of September ; the last, which was less than any of the former, took place on the 12th of January, 1835.

The Society then adjourned over Whitsun week to meet again on the 18th instant.

June 18, 1835.

Sir JOHN RENNIE, Knt., Vice-President, in the Chair.

June 18.—The following papers were read :

“ Discussion of Tide-Observations made at Liverpool.” By J. W. Lubbock, Esq., V.P. and Treas. R.S.

The author has here presented to the Society, by permission of the *British Association for the Advancement of Science*, a discussion by M. Dessiou of about 14,000 tide-observations made at Liverpool, on the plan similar to that adopted with regard to the London Dock observations. The first book contains the moon's transits, classified

with the moon's parallax and declination, together with the date and corresponding time and height of high water; the height of the barometer is also added to the observations of about four years. The second book contains the same quantities, classified further according to the different calendar months, and for each minute of the moon's horizontal parallax. The third book contains a similar classification for the moon's declination. The average results are given in tables at the end.

Some remarks are subjoined on the registers of the observations taken at the London and St. Katherine's Docks; from which it appears that the tide is about five minutes earlier in the former than in the latter of these two places; and that the difference in height is about five feet.

"On the Star-fish of the genus *Comatula*, demonstrative of the *Pentacrinus Europæus* being the young of our indigenous Species." By John V. Thompson, Esq., F.L.S., Deputy Inspector General of Hospitals. Communicated by Sir James Macgrigor, Bart., F.R.S.

The author states that the *Pentacrinus Europæus*, which is fixed by its stem to other bodies, and consequently deprived of the power of locomotion, is produced from the ova of the *Comatula*, and becomes in a subsequent stage of its evolution detached, assuming the form of this genus of *Asterida*, and capable of moving freely in the ocean; at one time crawling amongst submarine plants, at others floating to and fro, or swimming in a manner similar to *Medusæ*.

"On the Ova of Women and Mammiferous Animals, as they exist in the Ovaries before Impregnation." By Thomas Wharton Jones, Esq. Communicated by Robert Lee, M.D., F.R.S.

After reviewing the accounts given by various authors of the structure of the ovaries, corpora lutea, and ova in different tribes of animals, the author proceeds to the anatomical description of the ovaries in the human species, which he finds to correspond with those of the Mammalia generally, and to consist of a *parenchyma* or *stroma*, and an envelope or *indusium*, derived from the peritoneum. The stroma immediately under the peritoneal envelope is condensed into the form of a tunic, to which the peritoneum closely adheres, and which has received the name of the *tunica albuginea*, or *indusium proprium*. The vesicles of De Graaf are imbedded in this tunic, and are situated principally near the surface of the ovary: in the human species they are about one fifth of an inch in diameter. The proper capsule of the Graafian vesicle is composed of two layers; the outer being thin, dense, and vascular; the inner, thicker, softer, and more opaque. The nucleus of the vesicle consists of, 1st, a granular membrane; 2ndly, a coagulable granular fluid inclosed in the membrane; 3rdly, a circular mass or disc of granular matter, termed by Baer the *proligerous disc*, connected with the granular membrane on the prominent side of the vesicle, and presenting in its centre, on the side towards the interior of the vesicle, a small rounded prominence, called the *cumulus*, and on the opposite side a small cup-like cavity, hollowed out of the cu-

mulus; and, 4thly, the ovum, which is contained in the cavity just mentioned. The human ovum is so small as to be only just perceptible to the naked eye, being the 150th part of an inch in diameter. It has a soft transparent envelope of considerable thickness, and contains a substance composed of grains, adhering together by the intervention of a delicate mucous tissue. At the inner surface of the envelope, the author discovered a delicate transparent vesicle, about the 900th part of an inch in diameter, and having on one side a small elevation, which, projecting among the grains composing the walls of the granular sac, fixes the vesicle in its place. The author considers this vesicle as being analogous to that described by Professor Purkinje in the cicatricula of the immature eggs of birds, and which exists also in the ova of other oviparous animals, and is termed by Baer the *germinal vesicle*.

The author has also examined the ova of the cow, sheep, sow, rabbit, rat, and mouse; and has found in all these animals a germinal vesicle, differing in no essential particular from the human structure, and in size bearing a proportion to that of the ovum as one to six.

Although there is, at first sight, a considerable resemblance between the nucleus of the vesicle of De Graaf and the immature yolk of the egg of a bird, the author thinks, contrary to the opinion of Baer, that there is no real analogy between them; because, in the Graafian vesicle of the Mammalia there is no membrane surrounding its nucleus similar to the vitellary membrane of the ovum in birds, nor does this latter membrane appear first under the form of a granular membrane. The vesicle of Purkinje consists merely of a delicate capsule containing a fluid; while in the minute ovum of Mammalia there are found all the essential elements of the egg of birds and other Ovipara, namely, an external membrane, analogous to the vitellary membrane, but performing a different function; a granular membrane, containing a thin fluid, corresponding to the immature yolk of a bird's egg; and a vesicle in every respect analogous to the vesicle which Purkinje found in the hen's egg, while still lodged in the ovary. The author considers the granular membrane, proligerous disc, and granular fluid of the Graafian vesicle, as parts which are superadded, and of which there is no trace within the capsule of the ovary of a bird.

“Some Remarks on the difficulty of distinguishing certain genera of Shells; and on some Anomalies observed in the Habitations of certain species of Mollusca.” By John Edward Gray, Esq., F.R.S.

In opposition to the opinion of those geologists who consider that all shells of the same form and character have been inhabited by one genus of animals; that all the species of a genus live in similar situations; and that all the species of fossil shells, appearing from their character to belong to some recent genus, have been formed by animals which in their living state had the same habits as the most commonly observed species of that genus,—the author proposes to show, first, that shells having the appearance of belonging to the same natural genus are sometimes inhabited by very different animals; and, secondly, that some species of shell-bearing molluscous animals live in dif-

ferent situations from the majority of the species of the genus to which they belong, or even have the faculty of living in several different situations. Thus, although the animals inhabiting the shells belonging to the genera *Patella* and *Lottia* are extremely dissimilar in many essential features of their organization, the shells they form cannot be distinguished from one another by any known character. In other instances, when the animals are very different, the distinctive characters of the respective shells belonging to them are so slight as to be insufficient for the purpose of classing them under separate species; and this difficulty of discrimination must be much increased in the cases of fossil shells, especially of those which have no strictly analogous forms among recent shells.

In support of the position advanced in the second part of the paper, namely, that numerous exceptions occur to the identity of habitation among all the species of the same genus of conchiferous Mollusca, the author adduces examples: 1st, where the species of a genus are found in more than one situation, as on land, in fresh and in salt water; 2ndly, where one or more species of a genus, the species of which generally live in fresh water, are found in salt or in saltish water; 3rdly, where one or more species of a genus, which is generally found in the sea, are, on the contrary, found in fresh water; and, 4thly, where the same species of shell is found both in salt and in fresh water.

“On the supposed Existence of Metamorphoses in the Crustacea.” By J. O. Westwood, Esq., F.L.S. and Secretary to the Entomological Society. Communicated by J. G. Children, Esq., Sec. R.S.

The author refers the principal modifications of form which occur during the progressive development of animals to the three following heads: 1st, that of an animal produced from the egg in the form which it is destined to retain through life, its only change consisting in a series of moultings of the outer envelope, attended merely by an increase of size, and not by the acquisition of new organs; 2ndly, when the animal, at its exclusion from the egg, exhibits the form which it continues to possess, subject to a series of moultings, during several of the last of which certain new organs are gradually developed; and, 3rdly, when the form of the animal, at its exclusion from the egg, is totally different from that under which it appears at the later periods of its existence; such change of form taking place during two or three of its general moultings, and consisting, not only in the variation of the form of the body, but also in a complete change in the nutritive and digestive systems, and in the acquisition of various new organs. This last phenomenon peculiarly characterizes what is termed a *metamorphosis*.

It is the received opinion among naturalists that the Crustacea do not undergo metamorphoses, properly so called, and that the transformations they exhibit consist merely in the periodical shedding of the outer envelope. The object of the present paper is to establish the correctness of this opinion, in opposition to that of Mr. J. V. Thompson, who has laid claim to the discovery that the greater number of the animals belonging to the class Crustacea actually undergo

metamorphoses of a peculiar kind, and of a different character from those of insects. Mr. Thompson's views are founded upon some circumstances which he has observed in certain animals of the genus *Zoea* of Bosc, and which have been recorded by Professor Slabber, and which have led Mr. Thompson to believe that, of these animals, some were the young of the *Cancer Pagurus*, or common crab, and others the young of the *Astacus Pagurus*, or common lobster; and these views are supposed by him to be corroborated by the annual peregrinations of the land crabs to the sea-side, for the purpose of depositing their eggs, rendered necessary by the aquatic habits and conformation of the young. The author proceeds to examine at length the arguments on which Mr. Thompson has founded these opinions, and adduces his reasons for concluding that they are erroneous, and that no exception occurs to the general law of development in the Crustacea, namely, that they undergo no change of form sufficiently marked to warrant the application to them of the term *metamorphosis*.

"Memoranda relating to a Theory of Sound." By Paul Cooper, Esq. Communicated by J. G. Children, Esq., Sec. R.S.

The author, expressing his dissatisfaction with the commonly received theory of the propagation of sonorous undulations by an elastic medium, advances the hypothesis that each particle of an elastic body, after receiving an impulse in a particular direction, and communicating that impulse to the adjoining particle, instead of being thereby brought to a state of rest, is carried back by its elasticity with a velocity which continues its motion beyond the point from which it originally set out, and is thrown into continual vibration, in a manner analogous to the motion of a pendulum. He endeavours, on the principle of a continual transfer of the state of each particle to the adjacent particles, to explain the phenomena of continued sound arising from a prolonged succession of vibrations.

"A Theory of the Tides, including a Theory of the Formation and Propagation of Waves." By the same.

The author applies the principle announced in his paper on the Theory of Sound, namely, that of a continual transfer of state between the adjacent atoms of a medium, to the case of oscillating columns of fluid, constituting waves and tides.

"On the influence of the Respiratory Organs in regulating the Quantity of Blood within the Heart." By James Wardrop, Esq. Communicated by the Hon. Captain De Roos, R.N., F.R.S.

The author observes that the act of inspiration tends not only to favour the passage of the blood into the venæ cavæ, but also to detain it in the pulmonary vessels,—in consequence of the expansion of the lungs allowing of its more ready ingress into the pulmonary arteries, and impeding its exit by the veins—and thus retards its return to the heart. On the other hand, the collapse both of the lungs and of the parietes of the chest, during expiration, assists the transmission of arterial blood from the lungs into the left cavities of the heart, and

promotes its passage into the aorta. Thus he considers inspiration as an auxiliary to the venous, and expiration to the arterial, circulation; the first acting like a sucking, and the latter like a forcing pump, in aiding the power of the heart. On this principle he explains the influence exerted on the circulation and on the action of the heart by various modes of respiration, whether voluntary or involuntary, in different circumstances. Laughter, crying, weeping, sobbing and sighing, &c., he considers as efforts made with a view to effect certain alterations in the quantity of blood in the lungs and heart, when the circulation has been disturbed by mental emotions.

“Experimental Researches in Electricity.” Tenth Series. By Michael Faraday, Esq., F.R.S. D.C.L., &c. &c.

This paper relates altogether to the practical construction and use of the voltaic battery. Guided by the principles developed in former series, the author concluded that in voltaic instruments in which the copper surrounded the zinc, there was no occasion for insulation of the contiguous coppers, provided they did not come into metallic contact; and therefore in the construction of some new instruments he interposed paper only between the coppers instead of the usual insulating plate of porcelain or glass. The battery thus constructed is essentially the same with Dr. Hare’s; and the author recommends even his form of trough for the purpose of putting the acid on to, and moving it from the plates. By attending to certain points described, as many as 40 pairs of plates could be packed into a space not more than 15 inches in length, and thus a very portable, and, at the same time, powerful and convenient trough might be obtained.

In comparing this form of trough with others, the author used acids of constant strength, took note of their quantity, allowed them to act in the troughs until the power of the apparatus had nearly ceased, estimated the quantity of effect by his volta-electrometer, and then estimated the quantity of zinc in the battery employed in producing the effect by the results of an analysis of a given portion of the exhausted charge. In this way it was easy to tell how much zinc was dissolved from any one plate, or from all the plates, and to compare it with the quantity of water decomposed in the volta-electrometer. Thus, with a perfect battery of 40 pairs of plates, an equivalent of water decomposed in the volta-electrometer would be the result of the solution of an equivalent of zinc from each zinc plate, or forty equivalents in the whole; but with a battery not so perfect, a greater proportion of zinc would be dissolved by the acid in the cells.

When the new battery was thus compared with that of the ordinary form, it was found to have greatly the advantage. Thus, with 40 pairs of plates, the former lost 2·21 equivalents at each plate, and the latter 3·54. With 20 pairs of plates, the former lost 3·7 per plate, and the latter 5·5. With 10 pairs of plates, the former lost 6·76 per plate, and the latter 15·5. The author refers to two difficulties still existing in the construction of the battery, but considers its value so great as to deserve receiving that degree of attention, by the application of which these difficulties may be removed.

The author then investigated many other practical points in the use of the battery, ascertaining the influence of various circumstances in the manner already described. Thus he found nitric acid to give a higher result of voltaic action than sulphuric or muriatic acid; the quantity of zinc dissolved in order to produce decomposition of an equivalent of water being only 1.85 per plate when nitric acid was used, 3.8 when muriatic acid was used, and 4.66 when sulphuric acid was employed. The acid which he afterwards used as the best for ordinary purposes consisted of 200 water, 4.5 oil of vitriol, and 4 nitric acid.

The mode of proof adopted by the author was of course independent of the strength of the acid; as was shown by making experiments with the same acid at very different strengths; thus, when nitric acid was used, and the strengths were as 1, 2, and 4, the proportion of zinc dissolved was very nearly the same for the water decomposed. The same result was obtained when sulphuric acid was employed.

The different circumstances of uniformity of charge—purity of zinc—foulness of the zinc plates—new and old plates—vicinity of the copper and zinc—doubling of the copper—first immersion of the plates—number of plates—size of the plates and simultaneous decompositions—were then considered, and such of them as would admit of experimental comparison in the manner already described were put to this test.

The Society then adjourned over the long vacation, to meet again on the 19th of November next.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1834-1835.

No. 22.

November 19, 1835.

JOHN WILLIAM LUBBOCK, Esq., Vice-President and Treasurer,
in the Chair.

The Rev. William Bentwick Latham Hawkins, M.A., was elected a Fellow of the Society.

“On the Empirical Laws of the Tides in the Port of Liverpool.”
By the Rev. William Whewell, M.A., F.R.S.

The author employs the results of the discussion of sixteen years of tide observations made at Liverpool, published by Mr. Lubbock in the Philosophical Transactions for the present year, in testing and improving the formulæ, expressing the mathematical laws of the inequalities of the phenomena of the tides, which had already been deduced by the author from the London tide observations. He finds that the Liverpool observations have not only confirmed, in the most satisfactory manner, these formulæ, but have furnished the means of greatly improving them. The corrections for lunar parallax and declination, which, as far as they depended on the former investigation, might be, considered as in some measure doubtful, and only locally applicable, have now been fully verified as to their general form; the nature of the local differences in the constants of the formulæ has also, in part, come into view; and the investigation has, moreover, shown that, notwithstanding the great irregularities to which the tides are subject, the results of the means of large masses of good observations agree with the formulæ with a precision not far below that of other astronomical phenomena. The formulæ obtained point directly to a very simple theory of the circumstances of tides, namely, that the tide at any place occurs in the same way as if the ocean assumed the form of equilibrium, corresponding to a certain antecedent time, and different place. The ocean, in its position of equilibrium, would have the form of a spheroid, of which the pole would revolve round the earth, following the moon at a certain distance of terrestrial longitude. This distance is termed by the author the *retroposition of the theoretical tide in longitude*, its mean value being what he has termed in other communications, the *corrected establishment* of the place. If from an original equilibrium tide, a derivative tide were sent off, along any chan-

nel, in which it is no longer influenced by the forces of the moon and sun, it would take a certain time in reaching any place in that channel, and the circumstances of the tide at that place would not depend on the positions and distances of the moon and sun at the time when the tide happens, but on the positions and distances of those luminaries at a certain time, anterior to the time of the tide, by the interval occupied in the transmission of the tide along the channel. This interval of time, which, in his former papers, the author had called *the age of the tide*, he here terms the *retroposition of the theoretical tide in time*.

Adopting this phraseology, the author finds that the phenomena of the Liverpool tides may be expressed as follows.

1. The effects which the changes of the moon's force produce on the tides are the same as the effects which those changes would produce upon a retroposited equilibrium tide.

2. The retroposition of the tide in longitude is affected by small changes, which changes are proportional to the variations in the moon's force.

3. The retroposition of the tide in time is also affected by small changes, which changes depend on the variations in the moon's force.

On the hypothesis that an equilibrium tide give rise to the Liverpool tides, we must suppose that the channel by which they are transmitted occupies in length, from west to east, $11^{\text{h}} 6^{\text{m}}$ of longitude; or we may suppose the tide spheroid to lie behind the position of equilibrium by a certain space; and the longitude occupied by the channel from end to end, may be supposed to make up the rest of the $11^{\text{h}} 6^{\text{m}}$, the retroposition of the tide in longitude. The author proceeds to show how the circumstances of the tide may be hypothetically represented on these suppositions; although it is not to be imagined that these hypotheses are strictly accordant with the true state of the case. As the general laws of the tides at other places must resemble those at Liverpool, they will of course be capable of being represented in a similar manner.

The remainder of the paper is occupied by a comparison of the data of observations at London and Liverpool, and by an investigation of the corrections in the formulæ thence resulting.

November 26, 1835.

Sir JOHN RENNIE, Knt. Vice-President, in the Chair.

Robert Alexander, Esq.; Charles Elliott, Esq.; and Sir William Molesworth, Bart., M.P., were elected Fellows of the Society.

"Observations on Halley's Comet, made at Mackree, Sligo, in the Months of August, September, October and November 1835." By Edward J. Cooper, Esq. Communicated by Capt. Beaufort, R.N., F.R.S.
 These observations are communicated in the state in which they were taken, and without the corrections for refraction and parallax, with a view to assist computers in the calculation of a new approxi-

mate orbit. They were made principally with the author's equatorial telescope, having a focal length of 25 feet 3 inches, and a clear aperture of 13·3 inches. Some few, however, were taken with the finder, which is 6 feet 6 inches in focal length, and 4·9 inches clear aperture. The eye-pieces used were, one by Frauenhofer (an illuminated wire-micrometer), one by Messrs. Troughton and Simms (an illuminated field-micrometer), a comet eye-piece, and the ordinary eye-piece of the finder. The first of these had a magnifying power of about 400, the second of 226, the third of about 95, and the fourth about 40.

“An Account of the great Earthquake experienced in Chili, on the 20th of February 1835,” with a Map. By Alexander Caldcleugh, Esq., F.R.S.

An idea formerly prevailed among the inhabitants of Chili, that the earthquakes of those regions take place at certain regular periods; but it is now sufficiently proved, from the numerous catastrophes of this kind which have occurred during the present century, that they may happen indiscriminately at all times, and in all states of the atmosphere. The author is disposed to place but little reliance on most of the supposed prognostics of these convulsions: but he mentions that, previously to the earthquake described in the present paper, there were seen immense flocks of sea birds, proceeding from the coast towards the Cordillera, and that a similar migration had been noticed prior to the great shock of 1822. From his own observations, he concludes that the barometer usually falls shortly before any considerable shock, and that it afterwards rises to its ordinary mean height. Both before, and also at the time of the convulsion, the volcanos of the whole range of the Cordillera were observed to be in a state of extraordinary activity.

The earthquake began at half-past eleven o'clock in the morning of the 20th of February. The first oscillations of the earth were gentle, and attended with little noise: they were succeeded by two extremely violent tremors, continuing for two minutes and a half, the principal direction of the motion being from south-west to north-east; and they were attended by a loud report, apparently proceeding from the explosions of a volcano to the southward. All the buildings of the town of Concepcion were thrown down during these undulations. At the expiration of half an hour, when the inhabitants, who, on the first alarm, had fled to the neighbouring heights, were preparing to return to their houses, it was observed that the sea had retreated to such a distance that the ships in the harbour were left dry, and all the rocks and shoals in the bay were exposed to view. At this period an immense wave was seen slowly advancing towards the shore, and, rolling majestically onwards, in ten minutes reached the city of Concepcion, which was soon overwhelmed in a flood of an altitude of 28 feet above high-water mark. The few persons who had remained in the town had but just time to make their escape, and to behold from the rising grounds, the complete submersion of the city. All objects that were movable were swept away into the ocean by the reflux of this great wave, which was succeeded by several similar, but smaller

waves, completing the work of destruction, and leaving behind them, on their final retreat, a scene of universal havoc and desolation.

The island of Santa Maria, which is situate to the southward of the bay of Concepcion, and is about seven miles broad, and two long, remained, after the earthquake, permanently elevated at least ten feet above its former position; and a similar change was found to have taken place with regard to the bottom of the sea immediately surrounding the island. The amount of this elevation was very accurately ascertained by the observations of Capt. Fitzroy, who had, previously to the earthquake, made a careful survey of the shores of that island; thus supplying the most satisfactory and authentic testimony to this important fact.

The author gives, in the course of the paper, several particulars relating to the effects of the earthquake in different parts of the Chilian coast; the oscillations appearing to have extended to the north as far as Coquimbo, and to the east as far as Mendoza, at the ridge of the great chain of the Andes. Vessels navigating the Pacific Ocean, within a hundred miles of the coast, experienced the shock with considerable force. Its influence was very perceptible in the island of Juan Fernandez, a basaltic mass 360 miles distant from the coast; as was shown by the sudden elevation and subsidence of the sea, which at one time rose 15 feet above the usual level, carrying all before it.

Anniversary Meeting, Nov. 30th, 1835.

JOHN WILLIAM LUBBOCK, Esq. V.P. and Treasurer, in the Chair.

Samuel Hunter Christie, Esq., as one of the Auditors on the part of the Society, reported that the balance in the Treasurer's hands at the present Audit was £218 13s. 7d.

The thanks of the Society were voted to the Auditors for their trouble in auditing the Treasurer's accounts.

The Secretary then read the following Report:

"The Council have to report the following statement of their proceedings during the past year, as far as they relate to matters of general interest to the Society.

"The vacancy in the offices of Assistant Secretary and Librarian, occasioned by the resignation of Mr. Hudson, has been supplied by the appointment of Mr. Robertson as Assistant Secretary, at a salary of 160*l.* per annum, with the use of a bed-room, sitting-room, coals, and candles; and with the understanding that his whole time shall be at the service of the Society; and of Mr. Shuckard as Librarian, at a salary of 50*l.* per annum: the duties of the latter being to have the care of the Library, under the superintendence of the Library Committee, to make all entries of books presented to, or bought by, the Society, and to give his attendance in the Library from 12 to 4 o'clock on two stated days in the week, Thursday being one of those days.

"By an arrangement made with the Trustees of the British Museum, a sum of 165*l.* has been placed at the disposal of the Library Committee for the purchase of books, in consideration of a grant by the Society to the British Museum of fifty-five volumes of Oriental Manuscripts.

"For the purpose of affording ready access to the upper bookshelves in the Library, the Council have directed a gallery to be constructed, which completely answers the desired object.

"The printing of the classed Catalogue, under the direction of Mr. Panizzi, is in great forwardness, and will soon be completed.

"Some inconvenience having been experienced from a great number of ballots for the election of Candidates for admission into the Society taking place during the same evening, when the times of election were limited to four meetings in the year, the Council have now removed that limitation, and restored the former practice of allowing elections to take place at any of the ordinary meetings of the Society.

"The Council have the satisfaction of reporting, that the Committee appointed, in compliance with the wishes of the Lords Commissioners of His Majesty's Treasury, and of the Honourable Board of Excise, for the purpose of giving their opinion on the construction of instruments and tables for ascertaining the strength of spirits, in reference to the charge of duty thereon, have nearly completed their labours, and will very shortly be ready with their Report.

"The Copley Medal for the present year has been awarded to William Snow Harris, Esq., for his 'Experimental Investigations of the Forces of Electricity of high Intensity,' contained in his paper published in the Philosophical Transactions for the year 1834 (p. 213; Proceedings, p. 277. No. 16.)

"One of the Royal Medals for the present year has been awarded to Michael Faraday, Esq., for his investigations and discoveries contained in the series of 'Experimental Researches in Electricity,' published in the Philosophical Transactions, and more particularly for the Seventh Series, relating to the definite nature of Electro-chemical Action. (Phil. Trans. for 1834, p. 77; and Proceedings, p. 261, No. 15.)

"The other Royal Medal for the present year has been awarded to Sir William Rowan Hamilton, Andrews Professor of Astronomy in the University of Dublin, for the papers published by him in the 16th and 17th volumes of the Transactions of the Royal Irish Academy, entitled 'Supplement to an Essay on the Theory of Systems of Rays,' and more particularly for those investigations at the conclusion of the third and last Supplement, which relate to the discovery of Conical Refraction.

"The Council propose, in the year 1838, to give one of the Royal Medals to the most important unpublished paper on Chemistry, and the other Medal to the most important unpublished paper on Mathematics, which shall have been communicated to the Royal Society for publication in its Transactions, after the present date and prior to the month of June 1838.

"The City of London have required a portion of the premises belonging to the Society in Coleman-street, under the Act of Parlia-

ment for making approaches to London Bridge. After ineffectual efforts to procure an arrangement more advantageous to the Society, it was finally agreed to sell to the City the whole of the premises, instead of dividing them, for the sum of £3150. This £3150, under the terms of the Act in question, is to be paid into the Court of Exchequer, and there remain until invested in freehold property, unless in some subsequent Act the insertion of a clause can be procured, authorizing its payment out of Court to the Royal Society. Every effort was made, in correspondence with the City authorities, to obtain payment of the money direct to the President and Council. But this point has not been conceded: and it appearing unadvisable legally to resist it, the Council have reluctantly given way.

"On the 26th instant the Seal of the Society was affixed to Deeds of bargain and sale of the freehold property in Coleman-street, from the Royal Society to the City of London, and also to a Deed of enfeoffment of the same property by the Society to the City, in consideration of £3150 to be paid into the Court of Exchequer."

The Secretary also read the following List of Fellows deceased since the last Anniversary: viz.

On the Home List.—His Royal Highness the Duke of Gloucester; Sir William Blizard, Knt.; Sir David Barry, Knt.; The Marquis of Breadalbane; The Earl of Charleville; The Bishop of Cloyne; The Earl of Darnley; Lord De Dunstanville; Colonel Sir Augustus Simon Frazer, K.C.B.; Major-General Hardwicke; Captain Kater; Rev. Thomas Robert Malthus; Thomas James Mathias, Esq.; William George Maton, M.D.; Rev. Robert Morrison, D.D.; Michael Thomas Sadler, Esq.; Richard Sharp, Esq.; William Smith, Esq.; Edward Troughton, Esq.; Sir George Lemon Tuthill, Knt. M.D.; Ralph Watson, Esq.

On the Foreign List.—Frederich Stromeyer.

The Secretary stated that of these only three, namely, Captain Kater; John Brinkley, Lord Bishop of Cloyne, and Edward Troughton, Esq. have contributed papers to the Royal Society.

Capt. Kater contributed the following papers, fifteen in number, to the Philosophical Transactions.

1. On the light of the Cassegrainian Telescope, compared with that of the Gregorian. (Phil. Trans. 1813, p. 206.)

Having remarked the superiority in the performance of a Cassegrainian telescope over those of similar dimensions in the Gregorian construction, Capt. Kater made a series of experiments to determine the comparative excellence of these two methods of constructing that instrument. From a mean of these experiments and from a consideration of all the circumstances in which they were made, he concludes that the comparative superiority of the Cassegrainian over the Gregorian telescope of equal apertures and magnifying powers, is as 20 to 11, or very nearly twice as great. He conjectures that the superiority of illumination in telescopes of the former construction may possibly depend on their being exempt from the mutual interference of rays meeting in the same point, as happens in the Grego-

rian telescope, when the small speculum receives the rays after they have arrived at the focus, and after they have become sufficiently concentrated to interfere with each other's motion.

2. In a subsequent paper, the experimental research relating to the same subject is further prosecuted, and the conclusion arrived at is, that the illuminating power of the Cassegrainian telescope, as compared to the Gregorian, is in the proportion of $2\frac{1}{2}$ to 1.

3. His next communication to the Society relates to "An improved method of dividing Astronomical circles and other instruments." The general principle of the method there proposed is the same as that of the beam compass; but the apparatus, instead of having points, is furnished with two micrometer microscopes, adjustable to different distances, as aliquot parts of the arc or line to be divided. As a specimen of the method by which this apparatus is to be used, Capt. Kater describes the series of divisions and subdivisions which he thinks most convenient in a circle of two feet diameter.

4. The series of investigations in which Capt. Kater was engaged for many years, relative to the pendulum, commences with a paper entitled, "An account of experiments for determining the length of the Pendulum vibrating seconds in the Latitude of London." To ascertain with exactness the length of the seconds pendulum, an object of considerable importance in Physical Science, was scarcely possible by the methods which had been before resorted to: for the determination of the precise centre of oscillation of a body vibrating as a pendulum, depending as it does on the regular figure and uniform density of that body, involves difficulties which might be regarded as insurmountable. Capt. Kater fortunately discovered the means of solving this problem, by the application of a mathematical property already known to belong to the centre of oscillation, but which had never hitherto been practically employed with this view; namely, that this centre and the centre of suspension are reciprocal to one another: that is to say, that if a body, vibrating as a pendulum, be inverted, and suspended by its former centre of oscillation, its former point of suspension will become its centre of oscillation in its new position; and the vibrations in both positions will be performed in equal times. This property, therefore, furnishes an easy method of determining the exact distance between these two points, in a body of any form, or however irregular may be the densities of its different parts; for it will be only necessary, for that purpose, to provide a second axis of suspension, placed by estimation very near to the centre of oscillation, while the body is vibrating on its first axis, and also capable of adjustment as to distance, and as to its being kept in the line passing through the first axis, and the centre of gravity: thus by repeated trials of the number of vibrations performed, in a given time, by that body, when suspended on either of these two axes, and by altering the place of the moveable axis until this number becomes the same in both positions, we obtain a final adjustment which gives the exact distance between the centres of suspension and oscillation in that body; a distance equivalent to the length of a simple pendulum performing the observed number of vibrations in a certain time.

The mode of suspension adopted by Capt. Kater was the knife-edge, of which he points out the various advantages and disadvantages, and the methods he took for overcoming the difficulties of the inquiry. By employing the method of coincidences he found that the number of vibrations made by the pendulum in twenty-four hours might be obtained to within half a second of the truth in the space of eight minutes: and he then applied the usual correction for the extent of the arc of vibration, and also for the height of the place of observation above the level of the sea.

5. This paper was followed by another, "On the length of the French Metre estimated in parts of the English Standard:" in determining which he employed the same micrometer microscopes as were used in the pendulum experiments, bringing them alternately over the metre and over the standard scale, placed in the same plane parallel to and in contact with one another; care being taken that their temperatures were the same.

6. In the following year (1819) Capt. Kater gives an "Account of experiments for determining the Variation in the Length of the Pendulum vibrating Seconds, at the principal stations of the Trigonometrical Survey of Great Britain:" a paper which is full of laborious calculations, founded on the observations therein detailed. The investigation of the diminution of terrestrial gravity from the equator to the pole is pursued by the comparison of determinations of the length of the seconds pendulum at various stations: and is founded on the theorem demonstrated by Clairaut, that the sum of the two fractions expressing the ellipticity and the diminution of gravity from the pole to the equator is always a constant quantity, and is equal to $2\frac{1}{2}$ times the fraction expressing the ratio of centrifugal force, and that of gravity at the equator. The extreme degree of accuracy with which the force of gravitation may be determined by the apparatus employed by Capt. Kater, suggested to him the possibility of ascertaining by its means minute variations in this force observable in passing through a country composed of materials of various degrees of density: instances of the occurrence of which are given in this paper.

7. In the year 1823, Capt. Kater communicated to the Royal Society an account of experiments made with an invariable pendulum belonging to the Board of Longitude, by Sir Thomas Brisbane and Mr. Dunlop, at Paramatta in New South Wales, and thence deduces the fraction expressing the terrestrial compression.

8. In a paper which appeared in the *Phil. Trans.* for 1821 (p. 75.) Capt. Kater gives an account of the comparison which he instituted of various British Standards of Linear Measures for the purpose of accurately examining the standard yard employed by General Roy, in the measurement of a base on Hounslow Heath, as a foundation for the trigonometrical operations carried on by the Ordnance throughout the country. He found material differences to exist between the standards of Sir George Shuckburgh, of Bird, of the Royal Society, of General Roy's, and of the one constructed by Ramsden, which was used in the trigonometrical survey. Capt. Kater then proceeds to investigate the effect of these differences on the figure of the earth.

9. Sir George Shuckburgh Evelyn had, in the course of his inquiries respecting a standard of weights and measures, examined with great care the weights of a standard cube, cylinder, and sphere, and the methods employed for this purpose had been minutely described; but the mode of ascertaining the dimensions of these bodies had not been so fully detailed. Capt. Kater was accordingly desirous of re-investigating this latter branch of the subject before the Commissioners of Weights and Measures should make their final report. The apparatus he employed for this purpose, and the results of his experiments, are stated in a paper also published in the Philosophical Transactions for 1821.

10. These researches were continued by Capt. Kater in the year 1825; and the details are given in a paper published in the Phil. Trans. for 1826, and entitled "An Account of the construction and adjustment of the new standards of weights and measures of the United Kingdom of Great Britain and Ireland."

11. The series was completed in 1830 by the account he gives of the detection of a source of error in estimating the standard of linear measure, arising from the thickness of the bar, on the surface of which the lines are traced, and of the means he took to obviate it.

12. The attention of Capt. Kater was at one time directed to the ascertaining the best kind of steel for the construction of a compass needle, the most advantageous form to be given to the needle, and the most effective mode of communicating to it magnetism. Many curious and unexpected results were obtained in the course of this investigation.

13. A remarkable volcanic appearance in the moon being observed by Capt. Kater in February 1821, he communicated to the Society shortly afterwards an account of the phenomenon, which was published in the Phil. Trans. for the same year.

14. One of the greatest benefits conferred on science by Capt. Kater was his invention of the floating collimator, an instrument of which the object is to determine the situation of the line of collimation of a telescope attached to an astronomical circle, with respect to the zenith or the horizon in any one position of the instrument; or in other words, to determine the zero-point of the divisions on the limb: an operation which was before usually performed by the use of the level or the plumb-line, or by the reflexion of an object from the surface of a fluid. Each of these methods was liable to many inconveniences and defects; all of which are avoided in the floating collimator. The principles on which this instrument is constructed are two; the first is the property of a telescope employed by Gauss, and subsequently by Bessel, in virtue of which the cross wires of a telescope adjusted to distinct vision on the wire, may be distinctly seen by another telescope also similarly adjusted, at whatever distance the telescope may be placed, provided their axes coincide; in which case the rays diverging from the cross wires of either telescope, will emerge parallel from its object-glass, and will therefore be refracted by that of the other telescope to its sidereal focus, as if they came from an infinite distance. The other principle, which is employed as a substitute for the common level, is the invariability with respect

to the plane of the horizon, of the position of a body of determinate figure and weight, when floating on the surface of a fluid. Thus the telescope being attached to a box floating on mercury, and serving as a stand to the telescope, may be fixed either in a horizontal or a vertical position; in which latter case the reverse observations may be made by merely turning the float half round in azimuth.

15. The later improvements made by Capt. Kater in the vertical floating collimator are described by him in a subsequent paper published in the Philosophical Transactions for 1828. Besides obviating the sources of error arising from the necessity of transferring the instrument to different sides of the observatory, and of taking the float out of the mercury and replacing it at each observation, the vertical floating collimator has the further advantage of being adapted for use, not only with a circle, but also with a telescope, either of the refracting or reflecting kind. Such a telescope, furnished with a wire micrometer, and directed to the zenith, becomes a zenith telescope, free from all the objections to which the zenith sector, and the ordinary zenith telescopes with a plumb-line, are liable. From the greater degree of precision attainable by the employment of this instrument, from the facility of its construction, the readiness of its application, and the economy of time resulting from its use, the employment of the level and plumb-line may be wholly superseded.

John Brinkley, Lord Bishop of Cloyne, commenced his scientific career, while Andrews Professor of Astronomy in the University of Dublin, by a mathematical paper published in the Phil. Trans. for 1807, containing an investigation of the general term of an important series in the inverse method of finite differences. In 1810 Dr. Maskeleyne, then Astronomer Royal, announced to the Society by the communication of a letter from Dr. Brinkley, the supposed discovery by the latter of the annual parallax of α Lyrae, which he was confident exceeds $2''$. In 1818 he reported having met with apparent motions in several of the fixed stars which he could explain only by referring them to parallax. Among these α Aquilæ exhibited the greatest change of place. The observations made at the Greenwich observatory not being in accordance with those made at Dublin, Dr. Brinkley, in a subsequent paper published in the Phil. Trans. for 1821, institutes a new series of observations with a view to discover the source of this discordance. In conclusion he states his inability to discover any explanation of this difference, or to obtain any result opposed to his former conclusions. He remarks, however, that the discrepancies between his observations and those made at Greenwich may by some be considered as showing the great precision of modern observations, since the whole extent of the absolute difference is only one second. In the last paper on this important subject, which was published in the Phil. Trans. for 1824, Dr. Brinkley endeavours to form a correct estimate of the absolute and relative degrees of accuracy of the instruments at Dublin and at Greenwich. He first considers the difference of parallax between γ Draconis and α Lyrae, and secondly the absolute parallax of α Lyrae.

Four other papers by the same author are also contained in the Philosophical Transactions: the first in 1819, giving the results of

observations made at the observatory of Trinity College, Dublin, for determining the obliquity of the ecliptic, and the maximum of the aberration of light; the second, published in 1822, containing the investigation of the elements of a comet observed by Captain Basil Hall; the third published in 1824, on the North Polar distances of the principal fixed stars; and the last, which appeared in 1826, communicating the results of the application of Capt. Kater's floating collimator to the astronomical circle at the observatory of Trinity College, Dublin. He regards the results of these observations as highly favourable to the principle of the collimator, which he considers as a new astronomical power, and as even belonging to a more advanced era of practical astronomy than the present.

Mr. Edward Troughton is the author of a paper in the Phil. Trans. for 1809, entitled "An Account of a method of dividing Astronomical and other instruments by ocular inspection; in which the usual tools for graduating are not employed; the whole operation being so contrived, that no error can occur but what is chargeable to vision when assisted by the best optical means of viewing and measuring minute quantities." The intrinsic excellence of Mr. Troughton's method, as detailed in this paper, consists in the process of examination employed to correct the imperfections in laying down the divisions by methods which give only approximate degrees of accuracy.

The Treasurer made the following statements with respect to the Number of Fellows, State of the Finances, and the Receipts and Payments of the Society during the preceding year.

At the last Anniversary the Society consisted of 770 Members of whom there were,

11 Royal Personages,
44 Foreign Members, and
715 Home Members;

Since that date, there have died,

21 on the Home List, and
1 on the Foreign List;

and there have been admitted,

40 on the Home List, and
5 on the Foreign List. Of whom
11 have compounded during life, and
29 have engaged to pay the Annual Subscription of 4*l*.

The Society therefore now consists of

10 Royal Personages,
48 Foreign Members, and
735 Home Members;

making a total of 793 Members; of whom

598 have compounded for life,
41 are subject to an annual payment of 2*l*. 12*s*.
96 are subject to an annual payment of 4*l*. 0*s*.

The Treasurer then laid before the Meeting the following

*Statement of the Receipts and Payments of the Royal Society between
Nov. 29, 1834, and Nov. 28, 1835.*

1. RECEIPTS.

	£.	s.	d.
Balance in the hands of the Treasurer at the last Audit ..	192	7	5½
Weekly Contributions, at one shilling	111	16	0
Quarterly Contributions, at £1	234	16	6
Forty Admission Fees	400	0	0
Eleven Compositions for Annual Payments	500	0	0

Rents:—

One year's rent of estate at Mablethorpe: due at Michaelmas, (less the expenses of de- fending the suit, 16l. 13s.)	£.	s.	d.
Three quarters of a year's rent of premises in Coleman-street: due at Michaelmas	90	7	0
One year's rent of lands at Acton: due at Michaelmas	71	5	0
One year's rent of lands at Acton: due at Michaelmas	60	0	0
One year's fee-farm rent of lands in Sussex; land-tax deducted: due at Michaelmas ..	19	4	0
One fifth of the clear rent of an estate at Lam- beth Hill, from the Royal College of Phy- sicians, in pursuance of Lady Sadleir's will: due at Midsummer	3	0	0
	<hr/> 243 16 0		

Dividends on Stock:—

One year's dividends on 14,000l. Reduced An- nuities	420	0	0
<i>Pulteney Fund.</i>			
One year's dividends on 200l. 3 per cent. Consols ..	6	0	0
<i>Fairchild Fund.</i>			
One year's dividends on 100l. New South Sea Stock ..	3	0	0
<i>Rumford Fund.</i>			
One year's dividends on 2161l. 0s. 10d. 3 per cent. Consols	64	16	8
<i>Donation Fund.</i>			
One year's dividends on 3820l. 19s. 3d. 3 per cent. Consols	114	12	6
	<hr/> 608 9 2		

Miscellaneous Receipts:—

Sale of the Oriental Manuscripts to the British Museum	163	4	0
Sale of Philosophical Transactions	444	9	3
Sale of Abstracts of Papers	17	6	8
Sale of Sir H. Davy's Discourses	0	3	0
Sale of Coins and Medals	44	16	6
	<hr/> 669 19 5		

Total..... £2961 4 6½

2. PAYMENTS.

	£.	s.	d.
<i>Lady Sadleir's Legacy</i> .—The Poor of the Parish, in pursuance of Lady Sadleir's Will.	3	0	0
<i>Fairchild Lecture</i> .—The Rev. J. J. Ellis, for delivering the Fairchild Lecture of 1834	3	0	0
BAKERIAN LECTURE.—Charles Lyell, Jun., Esq., for the Bakerian Lecture	4	0	0
<i>Rumford Medal</i> .—M. Melloni, two year's dividend on the Rumford Augmentation Fund, January 8th, 1835	69	11	10
Mr. Wyon, for Gold and Silver Rumford Medal	64	0	0

Salaries :—

	£.	s.	d.
Dr. Roget, one year, as Secretary	105	0	0
J. G. Children, Esq., one year, as Secretary..	105	0	0
Ditto for Index to Phil. Trans.	5	5	0
C. Konig, Esq., one year as Foreign Secretary	20	0	0
Mr. Robertson, one year, as Assistant-Secretary	160	0	0
Mr. W. E. Shuckard, Librarian	30	17	0
Mr. Gould, one year, as Porter	60	0	0
Mr. Hudson for one month's salary	20	16	8
	506	18	8

Mr. Panizzi : On account ; for preparing a Catalogue of the Library	300	0	0
Fire Insurance, on the Society's Property	22	11	6
Mr. Robertson : Gratuity	20	0	0
Mrs. Coppard : Gratuity	10	0	0

Bills :—

Taylor :

Printing the Phil. Trans., 1834, part 2	216	2	6
Printing the Phil. Trans., 1835, part 1	181	11	0
Printing and Paper of Proceedings, Nos. 17—21	34	9	6
Printing Proceedings of Excise Committee	18	14	0
Miscellaneous Printing : Circulars, Lists of Fellows, Ballot-lists, Statement of Payments, and Minutes of Council, &c. ..	102	0	6

Bowles and Gardiner :

Paper for the Phil. Trans., 1835, parts 1 and 2	121	16	0
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Basire :

Engraving and Copper-plate Printing for the Phil. Trans., 1835, parts 1 and 2, &c.	67	7	6
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Carried forward.....£742 1 0 1003 2 0

	£.	s.	d.	£.	s.	d.
Bills:—						
Brought forward.....	742	1	0	1003	2	0
Sowerby :						
Engraving for Phil. Trans.....	6	16	6			
Gardner :						
Engraving for Phil. Trans.,.....	14	10	0			
Vizetelly and Branston :						
Wood Engravings for Phil. Trans. 1835, part 1.....	8	12	0			
Gyde :						
Sewing and Boarding 1783 Parts of Phil. Trans.	60	15	4			
Boarding 201 Sets of Abstracts, Sewing Adjudication of Medals, &c.	36	16	9			
				869	11	7
Few & Co., Solicitors	113	13	4			
Mr. Higgins: Surveying Coleman-street Pro- perty	31	10	0			
Mr. Russell: for calculation of Tables for the Excise Committee (to be repaid by the Lords of the Treasury)	25	0	0			
Mr. Williamson, for a Plate Chest	3	17	0			
Tuckett :						
Bookbinding	34	16	8			
Chappell :						
Stationery	36	16	6			
Saunderson :						
Shipping expenses	11	1	5			
Brecknell and Turner :						
Wax Lights, Candles, and Lamp Oil	72	14	6			
Skelton :						
Cleaning Chandeliers; Fenders; and re- pairing Lamps and Locks	11	15	9			
Cubitt :						
Book-shelves in New Room	72	13	0			
Fitting up the Meteorological Room.....	13	19	10			
Pryer and Spice :						
Furniture for Mr. Hudson's new room....	14	10	0			
Snell :						
Gallery for Library.....	131	9	4			
Furniture for Mr. Robertson's room.....	30	12	6			
New Carpet, Window Blinds, Carpet-beat- ing, &c.	22	7	0			
Cobbett and Son :						
Window-cleaning and Glazing	2	12	4			
Gwillim :						
Large Mats, Brushes, Fire-wood, &c.	15	17	0			
Carried forward	£645	6	2	1872	13	7

	£.	s.	d.	£.	s.	d.
Bills:—						
Brought forward.....	645	6	2	1872	13	7
Baker:						
Upholstery.....	11	6	0			
Hermon:						
Cleaning Staircase, &c.	10	14	5			
Arnold and Dent:						
Cleaning and Regulating Clocks.....	2	17	9			
				670	4	4
Books bought on account of the Money received from the British Museum:						
Baillière: Books,—on account.....	50	0	0			
Simpkin and Marshall: Ditto.....	2	10	8			
Pickering: Ditto.....	7	0	0			
Bohn: Ditto.....	2	2	0			
Weale: Ditto.....	4	0	6			
				65	13	2
Parish Rates and Petty Charges:						
Taxes and Parish Rates.....	31	19	9			
L'Institut Journal.....	3	5	0			
Postage and Carriage.....	18	6	3			
Extra Portage.....	4	11	7			
Expenses on Foreign Packets and Presents..	18	16	6			
Stamps.....	3	0	9			
Cleaning Library.....	2	13	6			
Charwoman's Wages.....	26	5	0			
Extra Charwoman's work.....	5	17	2			
Board and Wages of Mr. Hudson's Servant for one month.....	2	10	0			
Miscellaneous expenses.....	17	4	4			
				134	9	10
				£2743	0	11
Balance in the hands of the Treasurer	218	3	7½			
				£2961	4	6½

J. W. LUBBOCK, *Treasurer.*

November 28th, 1835.

The thanks of the Society were voted to the Treasurer for his able services in attending to its finances.

The Copley Medal, and the two Royal Medals for the present year were then delivered, pursuant to the awards made by the Council.

The Statutes relating to the Election of Council and Officers were then read by the Secretary; and Joseph Smith, Esq. and the Rev.

Dr. Jennings being nominated by the President, with the approbation of the Meeting, Scrutators to assist the Secretaries in examining the balloting-lists, the votes of the Fellows present were collected.

The ballot being taken, the Scrutators reported the following as the result.

President—His Royal Highness the Duke of Sussex, K.G.

Treasurer—Francis Baily, Esq.

Secretaries— { Peter Mark Roget, M.D.
John George Children, Esq.

Foreign Secretary—Charles Konig, Esq.

Other Members of the Council.

William Allen, Esq.	John William Lubbock, Esq.
Rev. William Buckland, D.D.	Herbert Mayo, Esq.
Samuel Hunter Christie, Esq.	Roderick Impey Murchison, Esq.
Rev. James Cumming.	Rev. Robert Murphy, M.A.
Davies Gilbert, Esq.	Sir John Rennie.
Joseph Henry Green, Esq.	William Henry Smyth, Capt. R.N.
Henry Holland, M.D.	Edward Turner, M.D.
William Lawrence, Esq.	Rev. William Whewell.

The thanks of the Society were then voted to the Scrutators for their trouble in assisting at the Election.

THE ROYAL SOCIETY IN ACCOUNT WITH THE BRITISH MUSEUM.

<i>Dr.</i>			<i>Cr.</i>		
	£.	s. d.	By Cash on account of the following disbursements:—		
				£.	s. d.
To Balance	258	15 0	Baillière; Books ...	50	0 0
Sale of Oriental MSS.	163	4 0	Simpkin and Marshall: Ditto	2	10 8
			Pickering: Ditto ...	7	0 0
			Bohn: Ditto	2	2 0
			Weale: Ditto	4	0 6
			Balance, Nov. 28, 1835...	356	5 10
	<hr/> £421 19 0 <hr/>			<hr/> £421 19 0 <hr/>	

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1835—1836.

No. 23.

December 10, 1835.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in
the Chair.

The following communication from the President to the Fellows of the Royal Society was read :

“ GENTLEMEN,

“ At the opening of the Session I think it right to express my anxiety to come amongst you again ; and I therefore trust that I need not repeat that as soon as my present infirmity is removed you may be sure of my readiness to take the chair. In the mean time I hope that the Members will not relax in their endeavours to uphold the character of the Royal Society ; and I shall look with confidence to the attendance of the Vice-Presidents for the maintenance of that order and regularity so necessary to be observed at all literary and scientific meetings. .

“ Kensington Palace, Dec. 10, 1835.

“ AUGUSTUS F., P.R.S.”

The following papers were read :

“Memoranda taken during the continuance of the Aurora Borealis of November 18, 1835.” By Charles C. Christie, Esq. Communicated by Samuel Hunter Christie, Esq., F.R.S.

The appearances described were seen from Deal, on the day mentioned in the title, from 9 to 20 minutes past 10 o'clock in the evening ; and consisted chiefly of a bright arch of light, of which the lower edge was sharply defined, surmounted on a dark cloud below, while the upper edge was shaded off into the cloudless and starlight sky, emitting large but faint luminous streaks, which issued upwards with great rapidity, exactly imitating flames agitated to and fro by a violent wind.

“ Démonstration complète du Théorème dit de Fermat : par François Paulet, de Genève, ancien élève de l'Ecole Polytechnique.” Communicated by P. M. Roget, M.D., Sec. R.S.

The theorem of which the author professes to give, in this paper,

the complete demonstration, is the following: "No power, beyond the second degree, of any quantity, can exist, capable of being resolved into the sum, or the difference, of two other powers of the same degree:" or, as it may still more generally be expressed, "If the exponents of three powers be multiplied by the same number, provided that number be greater than 2, neither the sum, nor the difference, of any two of the resulting quantities can ever be equal to the third quantity."

It was resolved unanimously,—“That the thanks of this Society be given to their Secretary John George Children, Esq., for the zeal and ability which he has uniformly displayed, and the many valuable services he has rendered, in promoting its objects.”

December 17, 1835.

SIR JOHN RENNIE, Knt., Vice-President in the Chair.

“Researches towards establishing a theory of the Dispersion of Light, No. II.” By the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

The author, in a preceding paper, published in the last part of the Philosophical Transactions, commenced a comparison between the results of M. Cauchy's system of undulations, expressing the theoretical refractive index for each of the standard rays of the spectrum, and the corresponding index found from observation in different media. Since that paper was communicated, he has received the account of a new series of results obtained by M. Rudberg, and comprising the indices for the standard rays in a prism of calcareous spar, and in a prism of quartz, both for the ordinary and the extraordinary rays; and also the ratios of the velocities in the direction of the three axes of elasticity, respectively, in Aragonite and Topaz. The author was accordingly led to examine this valuable series of data, and the comparison of them with the theory forms the subject of the present paper. He finds the coincidences of theory and observation to be at least as close as those already obtained from Fraunhofer's results, and to afford a satisfactory extension of the theory to ten new cases, in addition to those already discussed; and a further confirmation of the law assigned by the hypothesis of undulations.

A paper was in part read, entitled, “On the action of Light upon Plants, and of Plants upon the Atmosphere.” By Charles Daubeny, M.D., F.R.S., Professor of Chemistry and of Botany in the University of Oxford.

The Society then adjourned over the Christmas Vacation to meet again on the seventh of January next.

January 7, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

A paper was read, entitled, "Meteorological Journal kept at the Royal Observatory, Cape of Good Hope, from the 1st of June to the 31st of December, 1834." Communicated by Capt. Beaufort, R.N., F.R.S., Hydrographer to the Admiralty.

The observations recorded in this Journal are those of the barometer, and of two thermometers, one in, and the other out of doors; taken at sunrise, noon, sunset, and midnight, in each successive day from the 1st of June, 1834, to the end of the year.

"Some Account of the Volcanic Eruption of Cosiguina in the Bay of Fonseca, commonly called the Coast of Conchagua, on the Western Coast of Central America." By Alexander Caldcleugh, Esq., F.R.S.

The particulars recorded in this narrative are derived partly from a voluminous collection of official reports transmitted from the authorities in various towns to the government of Central America, and partly from the information of intelligent eye-witnesses of the phenomena. The eruption occurred on the 19th of January, 1835, and was preceded by a slight noise, accompanied with a column of smoke issuing from the mountain, and increasing till it took the form of a large and dense cloud, which, when viewed from a distance of ten leagues to the southward, appeared like an immense plume of white feathers, rising with considerable velocity and expanding in every direction. Its colour was, at first, of the most brilliant white; but it gradually became tinged with grey; then passed into yellow; and finally assumed a beautiful crimson hue. In the course of the following days several shocks of an earthquake were felt, the last of which were most terrific. On the morning of the 22nd, the sun had risen in brightness; but a line of intense darkness denoted the presence of the same cloud which had before presented such remarkable appearances, and which, extending with great rapidity, soon obscured the light of day; so that in the course of half an hour the darkness equalled in intensity that of the most clouded night: persons touched without seeing one another; the cattle hurried back to their folds; and the fowls went to roost, as on the approach of night. This atmospheric darkness continued with scarcely any diminution for three days; during the whole of which time there fell a fine impalpable dust, covering the ground at St. Antonio to the depth of two inches and a half, and consisting of three layers of different shades of grey colour: and for ten or twelve succeeding days the sky exhibited a dim and murky light. At Nacaome, to the northward of the volcano, the same degree of darkness was experienced, and the deposit of ashes was from four to five inches in depth, and exhaled a fetid sulphureous odour, which penetrated through every interstice in the buildings. The complete obscurity

was only occasionally broken by the lightning, which flashed in every direction, while the air was rent with loud and reiterated explosions like the discharges of artillery, which accompanied each eruption of volcanic matter, and conspired to strike the deepest terror, and to spread among the inhabitants a universal panic that the day of judgement was arrived. On the 24th the atmosphere became clearer, and the houses were found covered to the depth of eight inches with ashes, in which many small birds were found suffocated. Deer and other wild animals flew to the town for refuge, and the banks of the neighbouring streams were strewn with dead fish. In Segovia, and as far as eight leagues from the volcano, the showers of black sand were so abundant as to destroy thousands of cattle; and many were subsequently found whose bodies exhibited one mass of scorched flesh.

Within the Bay of Fonseca, and two miles from the volcano, it is stated that two islands, from two to three hundred yards in diameter, were thrown up, probably from the deposit of masses of scorice on previously existing shoals.

It was resolved unanimously:—"That the thanks of this Society be given to their Secretary Peter Mark Roget, Doctor of Medicine, for the zeal and ability which he has uniformly displayed, and the many valuable services he has rendered in promoting its objects."

January 14, 1836.

FRANCIS BAILY, Esq., V.P., and Treasurer in the Chair.

Dr. Daubeny's paper entitled, "On the action of Light upon Plants, and of Plants upon the Atmosphere," was resumed and concluded.

The objects of the experimental inquiries of which the author gives an account in this paper were, in the first place, to ascertain the extent of the influence of solar light in causing the leaves of plants to emit oxygen gas, and to decompose carbonic acid, when the plants were either immersed in water, or surrounded by atmospheric air. The plants subjected to the former mode of trial were *Brassica oleracea*, *Salicornia herbacea*, *Fucus digitatus*, *Tussilago hybrida*, *Cochlearia armorica*, *Mentha viridis*, *Rheum raphaniticum*, *Allium ursinum*, and several species of *Gramineæ*. Geraniums were the only plants subjected to experiment while surrounded with atmospheric air. Comparative trials were made of the action on these plants of various kinds of coloured light, transmitted through tinted glass, of which the relative calorific, illuminating, and chemical powers had been previously ascertained; and the results of all the experiments are recorded in tables; but no general conclusion is deduced from them by the author. He next describes a few experiments which he made on beans, with a view to ascertain the influence of light on the secretion of the green matter of the leaves, or rather to deter-

mine whether the change of colour in the chromule is to be ascribed to this agent. The third object of his inquiries was the source of the irritability of the *Mimosa pudica*, from which it appeared that light of a certain intensity is necessary for the maintenance of the healthy functions of this plant, and that when subjected to the action of the less luminous rays, notwithstanding their chemical influence, the plant lost its irritability quite as soon as when light was altogether excluded. He then examines the action of light in causing exhalation of moisture from the leaves; selecting Dahlias, Helianthus, Tree Mallows, &c., as the subjects of experiment. The general tendency of the results obtained in this series is to show that the exhalation is, *cæteris paribus*, most abundant in proportion to the intensity of the light received by the plant. He also made various comparative trials of the quantity of water absorbed, under different circumstances, by the roots of plants, and chiefly of the *Helianthus annuus*, *Sagittaria sagittifolia*, and the *Vine*. From the general tenor of the results of these and the preceding experiments, he is inclined to infer that both the exhalation and the absorption of moisture in plants, as far as they depend on the influence of light, are affected in the greatest degree by the most luminous rays; that all the functions of the vegetable economy which are owing to the presence of this agent, follow, in this respect, the same law; and that in the vegetable, as well as in the animal kingdom, light acts in the character of a specific stimulus. The author found that the most intense artificial light that he could obtain from incandescent lime produced no sensible effect on plants.

The latter part of the paper is occupied by details of the experiments which the author made with a view to ascertain the action of plants upon the atmosphere, and more especially to determine the proportion that exists between the effects attributable to their action during the night and during the day; and also the proportion between the carbonic acid absorbed, and the oxygen evolved.

His experiments appear to show that at least 18 per cent. of oxygen may be added to the air confined in a jar by the influence of a plant contained within it. He also infers that the stage of vegetable life at which the function of purifying the air ceases, is that in which leaves cease to exist. The author shows that this function is performed both in dicotyledonous and in monocotyledonous plants, in evergreens as well as in those that are deciduous, in terrestrial and in aquatic plants, in the green parts of eculents as well as in ordinary leaves, in Algæ and in Ferns as well as in Phanerogamous families. Professor Marcet has shown that it does not take place in Fungi.

The reading of a paper, entitled, "On the Anatomical and Optical Structure of the Crystalline Lenses of Animals, being the continuation of the paper published in the Philosophical Transactions for 1833." By Sir David Brewster, K.H., LL.D., F.R.S.,—was commenced.

January 21, 1836.

RODERICK IMPEY MURCHISON, Esq., V.P., in the Chair.

George Biddell Airy, Esq., M.A., A.R.; George Budd, B.A. and M.A.; the Rev. Humphrey Lloyd, M.A.; the Rev. William Taylor; and Charles Wheatstone, Esq.; were elected Fellows of the Society.

Sir David Brewster's paper, entitled, "On the Anatomical and Optical Structure of the Crystalline Lenses of Animals, being the continuation of the paper published in the Philosophical Transactions for 1833," was resumed and concluded.

The author has examined the structure of the crystalline lens of the eye of a great variety of animals belonging to each of the four classes of Vertebrata; and has communicated in this paper a detailed account of his observations, arranged according as they relate to structures more and more complex. In a former paper, published in the Philosophical Transactions for 1833, the lens of the Cod fish was taken as the type of the simplest of these structures, in as much as all the fibres of which it is composed converge, like the meridians of a globe, to two opposite points, or poles, of a spheroid or lenticular solid; both of which poles are situated in the axis of vision. The structure which ranks next in respect of simplicity is that exhibited in the Salmon, among fishes; in the Gecko, among reptiles; and in the Hare, among Mammalia. It presents at each pole two septa placed in one continuous line, in different points of which all the fibres proceeding from the one surface to the other have their origin and termination. A structure somewhat more complex is met with in the lenses of most of the Mammalia, and is particularly exemplified in the lion, the tiger, the horse, and the ox. Three septa occur at each pole in the form of diverging lines inclined to one another at angles of 120° . The next degree of complexity is presented in the lens of the whale, the seal, and the bear, which contain, instead of three, four septa on each side, placed at right angles to each other in the form of a cross. In some specimens of lenses of whales and seals the author observed two septa from each pole, forming one continuous line, from each of the extremities of which proceeded two others, which were at right angles relatively to one another: so that there were in all five on each surface. The most complex structure is that of the lens of the elephant, which exhibits three primary septa diverging at equal angles from the pole, and at their extremities bifurcating into two additional septa, which are inclined to each other at angles of 60° , these latter being the real septa, to which the fibrous radiations are principally related. In some lenses of the elephant the author found the three septa immediately proceeding from the poles exceedingly short, and approaching to evanescence; so that he has no doubt that occasionally they may be found to have disappeared, and that the other six septa will then all diverge from the poles, like the radii of a hexagon, at angles of 60° .

In all the preceding cases, where the arrangement of the fibres is symmetrical on the two sides, the septa on the opposite surface

of the lens occupy positions which are reversed with respect to one another; thus in the simple case of the double septa at each pole, the line formed by those of the posterior surface is situated at right angles to that formed by the septa of the anterior surface. Where there are three divergent septa at each pole, the direction of those on the one side bisect the angles formed by those on the other side; and again, where the septa form a rectangular cross, those of one surface are inclined 45° to those of the other surface.

It follows as a consequence of this configuration of the series of points which constitute the origins and terminations of the fibres, that all the fibres, with the exception only of those proceeding in a direct line from the extremities of any of the septa, must, in their passage from the one surface to the other, follow a course more or less contorted; and must form lines of double curvature; that is, curves of which none of the portions lie in the same plane.

The fibres of the lenses of quadrupeds gradually diminish in size from the equator or margin of the lens, where they are largest, to their terminations in the anterior or posterior septa. They are united together by small teeth like those of fishes; but, generally speaking, the teeth are smaller and less distinctly pronounced, and sometimes they are not seen without great difficulty.

In the lens of the turtle, as well as in that of several fishes, the arrangement of the fibres, instead of being symmetrical on the two sides, as is the case in all the preceding instances, is different on the anterior and posterior surfaces; there being two septa on the former, but none in the latter, which presents only a single polar point of convergence.

The author has directed much of his attention to the optical properties of these structures. The lens of the salmon depolarizes three series of luminous sectors; the inner and outer series being negative, and the intermediate series positive. The polarizing structure of the cornea is negative, and it depolarizes very high tints at its junction with the sclerotic coat. When a slice cut from the sclerotica nearly perpendicularly to the surfaces, and with parallel faces, is exposed to polarized light, it exhibits the system of biaxial rectilineal fringes, exactly like those in a plate of glass heated by boiling water or oil, when in the act of rapid cooling. The same alternation of properties with regard to polarization in the successive strata of the substance of the crystalline lenses is exhibited by other fishes which the author examined.

With respect to the final cause of these highly complicated arrangements, it is reasonable to conceive that the gradually increasing density of the fibres in each successive stratum from the surface to the centre is intended to correct spherical aberration: but the design of the other properties resulting from the arrangement of the fibres with reference to septa, in all their variations of number and position, and more especially the alternations of positive and negative structures, as exhibited by the action of the different strata in polarized light, has not even excited the ingenuity of conjecture, and will probably remain among the numerous problems destined to exercise the sagacity of another age.

January 28, 1836.

RODERICK IMPEY MURCHISON, Esq., V.P., in the Chair.

William Clark, M.D.; and Francis Marcet, Esq., were elected Fellows of the Society.

A paper was read, entitled, "Discussion of Tide Observations made at Liverpool." By J. W. Lubbock, Esq., F.R.S.

The chief purpose which the author has in view in presenting the tables accompanying this paper, which are a continuation of those published in the Philosophical Transactions for 1835, and are founded on the observations instituted by Mr. Hutchinson at Liverpool, is to exhibit the diurnal inequality in the height of high water, which is scarcely sensible in the river Thames, but which at Liverpool amounts to more than a foot. The diurnal inequality in the interval appears to be insensible.

The author has farther ascertained that Bernouilli's formulæ expressing the height of the tide, deduced from his theory of the tides, present a very remarkable accordance with observation.

February 4, 1836.

SIR JOHN RENNIE, Knt., Vice-President, in the Chair.

George William Drory, Esq.; Robert Edmund Grant, M.D.; and John Dillwyn Llewelyn, Esq.; were elected Fellows of the Society.

"Geometrical investigations concerning the Phænomena of Terrestrial Magnetism: Second Series,—On the number of points at which a magnetic needle can take a position vertical to the Earth's surface." By Thomas Stephens Davies, Esq., F.R.S. Lond. and Edin., F.R.A.S., of the Royal Military Academy, Woolwich.

This paper is intended as a continuation of the one by the same author published in the last volume of the Philosophical Transactions; in which it was proposed to investigate the mathematical consequences of the hypothesis of the earth being a magnet with two poles, or centres of force, situated anywhere either within, or at the surface, and of equal intensity, but of contrary characters: with the ultimate view of verifying this hypothesis by comparing its results, so deduced, with the phænomena furnished by observation.

In his former paper the author had shown that on this hypothesis the magnetic equator, or the locus of the points at which the magnetic needle takes a horizontal position, is one single and continuous line on the surface of the earth. In this paper his object is to prove that there are always two, and never more than two, points at the earth's surface, at which the needle takes a position vertical to the horizon.

At the close of his former paper the author had deduced the equation of the curve of verticity, that is, of the curve at any point

of which an infinitesimal needle being placed, it will always tend towards the centre of the earth, and consequently be vertical to the horizon at its point of intersection with the surface of the earth: but, owing to circumstances over which he had no control, he was unable, at that time, to write out an account of his investigations of the peculiar character of that curve, or to apply its properties to the determination of the latter problem: and these are more especially the objects to which the present paper is devoted.

The processes to which he has had recourse, with this view, are the following. He first transposes the rectangular equation of the curve into a polar equation, and finds that in the result the radius vector is involved only in the second degree; and hence that for every value of the polar angle there are two values of the radius vector; and never more than two; or, in other words, that no line drawn from the centre of the earth can cut the curve of verticity in more than two points. But as no means present themselves of ascertaining whether the values of (r) , the polar ordinates of the curve of contact, be always real or not, or how many values of (θ) , the other co-ordinate to that curve, are possible for any given value of r ; he abandons this method of inquiry, contenting himself with a few deductions respecting the general form of the locus, and proceeds to employ a different method.

The general system of his reasonings proceeds on the principle that as the magnetic curve itself, and the curve of verticity have one common and dependent genesis, a knowledge of the properties of the former must throw considerable light on those of the latter; and he is accordingly induced to enter into a more minute examination of the magnetic curve than had before been attempted. As both the polar and the rectangular equations of this curve are much too complex to afford any hope of success in their investigation, the author has recourse to a system of co-ordinates, which he terms the "*angular system*," and which was suggested to him originally by the form under which Professor Playfair exhibited this equation in Robison's Mechanical Philosophy. But as he has not yet published his investigations of the differential coefficients, and other formulæ necessary in the application of this system, he puts his results in a form adapted to rectangular co-ordinates; each rectangular co-ordinate being expressed in terms of his angular co-ordinates and the constants of the given equation; and by these means deduces the characters of the magnetic curve throughout its whole course.

The angular equation being

$$\cos \theta_1 \times \cos \theta_2 = 2 \cos \beta,$$

he finds, 1°, that the two equations, the convergent and the divergent, or that in which the poles are unlike, and that in which they are like, are both expressed by this equation, and essentially included in it: 2°, that the divergent branches on one side of the magnetic axis are algebraically and geometrically continuous with the convergent branches on the other side; the parameter (β) being the same in both cases: 3°, that the divergent branches are asymptotic, and the asymptote is capable of a very simple construction;

4°, that the continuous branches have the poles as points of inflexion, and that these are the only points of inflexion within finite limits: 5°, that a tangent at any point of the curve, or, which is the same thing, the direction taken by a small needle placed there, admits of easy construction: 6°, that when the parameter (β) is such as to cause the convergent and divergent branches to intersect, they do so in a perpendicular to the magnetic axis drawn from the poles: 7°, that the convergent branches are always concave, and the divergent always convex, to a line at right angles to the magnet, drawn from its middle,—besides other properties not less interesting, though less capable of succinct enunciation.

Having separated the branches belonging to the case of like poles from those belonging to the unlike ones in the magnetic curve, the author proceeds to a similar separation of the corresponding branches in the curve of verticity. In the former case the curve is composed of four branches infinite in length, having the magnetic axis for asymptotes, lying above that axis, and emanating from the poles to the right and left; and of two finite branches, continuous with those just described, and lying below the magnetic axis; one of which passes through the centre of the earth, and meets the other in the perpendicular from the middle of the axis; so that the whole system is constituted by one continuous curve, extending from negative infinite to positive infinite, and having the lines drawn from the centre of the earth to the magnetic poles as tangents at the poles; and no part of the curve lies between these tangents. It bears in form some general resemblance to a distorted conchoid; this curve not having either cusp or loop. In the second case, the curve is also composed of four branches, two finite and two infinite ones; the latter having the line drawn from the centre of the earth through the middle of the magnet as asymptotes, and both lying on the same side of it as the more distant pole; and the finite branches joining these continuously at the poles, and each other in the middle of the magnetic axis; the one from the nearer pole lying above the axis, and the one from the remoter pole lying below it. The branches, where they unite at the poles, have the lines drawn from the centre of the earth to the poles as tangents, and the lower infinite branch passes through the centre. The whole system of branches is comprised between the polar tangents; and the two systems are mutually tangential at the poles, and intersect each other at the centre; but they have no other point in common.

Lastly, the author proceeds to demonstrate that a circle (namely, the magnetic meridian) described from the centre of the curve of verticity, will always cut the convergent system in two points, but can never cut it in more than two. He remarks, however, that if we could conceive two poles of like kinds to exist without any other whatsoever, we might have either four points of verticity, or only two, according to circumstances; but he waves the discussion of this particular case, as being irrelevant to the purpose of his present inquiry.

Mr. Davies announces his intention of shortly laying before the

Society a continuation of these researches; devoting the next series to the points of maximum intensity.

"Mémorial on the Metamorphoses in the *Macroura*, or Long-tailed Crustacea, exemplified in the Prawn (*Palæmon serratus*)."
By John V. Thompson, Esq., F.L.S., Deputy Inspector-General of Hospitals. Communicated by Sir James Macgrigor, M.D., F.R.S., &c.

The author gives descriptions, illustrated by outline figures, of three different stages of growth of the Prawn; the first being that of the larva immediately on its exclusion from the egg; the second, at a later period, when it has acquired an additional pair of cleft members, and a pair of scales on each side of the tail; and the third, at a still more advanced stage of development, when it presents the general appearance of the adult Prawn, but still retains the natatory division of the members, now increased to six pair. The author thinks it probable that an intermediate stage of metamorphosis exists between the two last of these observed conditions of the animal.

February 11, 1836.

DAVIES GILBERT, Esq., Vice-President, in the Chair.

David Baillie, Esq., and Dr. Archibald Robertson, were elected Fellows of the Society.

A paper was in part read, entitled, "On Voltaic Combinations." In a letter addressed to Michael Faraday, Esq., D.C.L., F.R.S. Fullerian Professor of Chemistry in the Royal Institution of Great Britain, &c., &c. By John Frederick Daniell, Esq., F.R.S., Professor of Chemistry in King's College, London.

February 18, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

John Green Cross, Esq., was elected a Fellow of the Society.

The reading of Mr. Daniell's paper, entitled, "On Voltaic Combinations," in a letter to Michael Faraday, Esq., D.C.L., F.R.S., &c., was resumed and concluded.

The author, after expressing his obligations to Mr. Faraday for the important light which his late researches in electricity have thrown on chemical science, proceeds to state that in pursuing the train of inquiry which has thus been opened, he has obtained further confirmations of the truth of that great principle discovered and established by Mr. Faraday, namely, the definite chemical action of electricity; and has thence been led to the construction of a voltaic arrangement which furnishes a constant current of electricity for any required length of time.

For the purpose of ascertaining the influence exerted by the different parts of the voltaic battery in their various forms of combi-

nation, he contrived an apparatus, which he designates by the name of the *dissected battery*, and which consists of ten cylindrical glass cells, capable of holding the fluid electrolytes, in which two plates of metal are immersed; each plate communicating below, by means of a separate wire, which is made to perforate a glass stopper closing the bottom of the cell, with a small quantity of mercury, contained in a separate cup underneath the stopper, and with which electric communications may be made at pleasure through other wires passing out of the vessel on each side. The active elements of the circuit, which were adopted as standards of comparison, were, for the metals, plates of platinum and amalgamated zinc three inches in length by one in breadth; and for the electrolyte, water acidulated with sulphuric acid, in the proportion of 100 parts by volume of the former to 2.25 of the latter; this degree of dilution (giving a specific gravity of 1.0275,) being adopted, in order to connect the author's experiments with those of Mr. Faraday.

This dilute acid exerts scarcely any local action on amalgamated zinc; because the surface of the metal becomes covered with bubbles of hydrogen gas, which adhere strongly to it; and this force of heterogeneous adhesion appears to have an important influence on the phenomena both of local and of current affinity, and soon puts a stop to the decomposition of the water by the zinc. When a small quantity of nitric acid is added to the acidulated water, the same plate which in the former experiment resisted the action of the diluted sulphuric acid, is, in a few hours, entirely dissolved, without the extrication of any gaseous matter. This result is explained by the author on the supposition that the elements of the nitric acid enter into combination with the hydrogen as it is evolved, and that the opposing attraction of this latter substance is thus removed. The author finds, in like manner, that nascent hydrogen deoxidates copper, and precipitates it from its solutions upon the negative plate of the voltaic circuit.

A series of experiments performed with the dissected battery is next described; illustrating, in a striking manner, the difference of effects with relation to the quantity and the intensity of the electric current, consequent on the different modes of connecting the elements of the battery: the former property being chiefly exhibited when the plates of the respective metals are united together so as to constitute a single pair; and the latter being exalted when the separate pairs are combined in alternate series. The influence of different modifications of these arrangements, and the effects of the interposition of pairs in the reverse order, operating as causes of retardation, are next inquired into.

In the course of these researches, the author, being struck with the great extent of negative metallic surface over which the deoxidating influence of the positive metal appeared to manifest itself, as is shown more especially in the cases where a large sheet of copper is protected from corrosion by a piece of zinc or iron of comparatively very small dimensions, was induced to institute a more careful examination of the circumstances attending this class of phe-

nomena ; and was thus led to discover the cause of the variations and progressive decline of the power of the ordinary voltaic battery, one of the principal of which is the departure of the zinc on the platina plates ; and to establish certain principles from which a method of counteracting this evil may be derived. The particular construction which he has devised for the attainment of this object, and which he denominates the *constant battery*, consists of a hollow copper cylinder, containing within it a membranous tube formed by the gullet of an ox, in the axis of which is placed a cylindrical rod of zinc. The dilute acid is poured into the membranous tube from above by means of a funnel, and passes off, as occasion requires, by a siphon tube at the lower part ; while the space between the tube and the sides of the copper cylinder is filled with a solution of sulphate of copper, which is preserved in a state of saturation by a quantity of this substance suspended in it by a cullender, allowing it to percolate in proportion as it is dissolved. Two principal objects are accomplished by this arrangement ; first, the removal out of the circuit of the oxide of zinc, the deposit of which is so injurious to the continuance of the effect of the common battery ; and, secondly, the absorption of the hydrogen evolved upon the surface of the copper, without the precipitation of any substance which would lead to counteract the voltaic action of that surface. The first is completely effected by the suspension of the zinc rod in the interior membranous cell into which fresh acidulated water is allowed slowly to drop, in proportion as the heavier solution of the oxide of zinc is withdrawn from the bottom of the cell by the siphon tube. The second object is attained by charging the exterior space surrounding the membrane with a saturated solution of sulphate of copper, instead of diluted acid ; for, on completing the circuit, the electric current passes freely through this solution, and no hydrogen makes its appearance upon the conducting plate ; but a beautiful pink coating of pure copper is precipitated upon it, and thus perpetually renews its surface.

When the whole battery is properly arranged and charged in this manner, it produces a perfectly equal and steady current of electricity for many hours together. It possesses also the further advantages of enabling us to get rid of all local action by the facility it affords of applying amalgamated zinc ; of allowing the replacement of the zinc rods at a very trifling expense ; of securing the total absence of any wear of the copper ; of requiring no employment of nitric acid, but substituting in its stead materials of greater cheapness, namely, sulphate of copper, and oil of vitriol ; the total absence of any annoying fumes ; and lastly, the facility and perfection with which all metallic communications may be made and their arrangements varied.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1835-1836.

No. 24.

February 25, 1836.

HENRY HOLLAND, M.D., Vice-President, in the Chair.

A paper was read, "On an artificial Substance resembling Shell; by Leonard Horner, Esq., F.R.S. L. and Ed.: with an account of the examination of the same; by Sir David Brewster, K.H., LL.D., F.R.S., &c."

The author, having noticed a singular incrustation on both the internal and external surfaces of a wooden dash-wheel, used in bleaching, at the Cotton Factory of Messrs. J. Finlay and Co., at Catrine, in Ayrshire, instituted a minute examination of the properties and composition of this new substance. He describes it as being compact in its texture, of a brown colour, and highly polished surface, with a metallic lustre, and presenting in some parts a beautiful iridescent appearance: when broken, it exhibits a foliated structure. Its obvious resemblance, in all these respects, to many kinds of shell, led the author to inquire into its intimate mechanical structure, and into the circumstances of its formation. He found, by chemical analysis, that it was composed of precisely the same ingredients as shell; namely, carbonate of lime and animal matter. The presence of the former was easily accounted for; as the cotton cloths which are placed in the compartments of the wheel, in order that they may be thoroughly cleansed by being dashed against its sides, during its rapid revolutions, have been previously steeped and boiled in lime water. But it was more difficult to ascertain the source of the animal matter; this, however, was at length traced to the small portion of glue, which, in the factory where the cloth had been manufactured, was employed as an ingredient in forming the paste, or dressing, used to smooth and stiffen the warp before it is put into the loom. These two materials, namely lime and gelatine, being present in the water in a state of extreme division, are deposited very slowly by evaporation; and thus compose a substance which has a remarkable analogy to shell, not only in external appearance, and even pearly lustre, but also in its internal foliated structure, and which likewise exhibits the same optical properties with respect to double refraction and polarizing powers.

A letter from Sir David Brewster, to whom the author had sub-

mitted for examination various specimens of this new substance, is subjoined ; giving an account of the results of his investigations of its mechanical and optical properties. He found that it is composed of laminæ, which are sometimes separated by vacant spaces, and at others, only slightly coherent ; though generally adhering to each other with a force greater than that of the laminæ of sulphate of lime, or of mica ; but less than those of calcareous spar. When the adhering plates are separated, the internal surfaces are sometimes colourless, especially when these surfaces are corrugated or uneven ; but they are almost always covered with an iridescent film of the most brilliant and generally uniform tint, which exhibits all the variety of colours displayed by thin plates or polarizing laminæ. This substance, like most crystallized bodies, possesses the property of refracting light doubly ; and, as in agate and mother-of-pearl, one of the two images is perfectly distinct, while the other contains a considerable portion of nebulous light, varying with the thickness of the plate, and the inclination of the refracted ray. Like calcareous spar, it has one axis of double refraction, which is negative ; and it gives, by polarized light, a beautiful system of coloured rings. It belongs to the rhombohedral system, and, as in the *Chaux carbonatée basée* of Haüy, the axis of the rhombohedron, or that of double refraction, is perpendicular to the surface of the thin plates. As mother-of-pearl has, like arragonite, two axes of double refraction ; this new substance may be regarded as having the same optical relation to calcareous spar that mother-of-pearl has to arragonite.

The flame of a candle, viewed through a plate of this substance, presents two kinds of images ; the one bright and distinct, the others faint and nebulous, and having curvatures, which vary as the inclination of the plate is changed : the two kinds being constituted by oppositely polarized pencils of light. On investigating the cause of these phenomena, Sir David Brewster discovered it to be the imperfect crystallization of the substance ; whence the doubly refracting force separates the incident light into two oppositely polarized pencils, which are not perfectly equal and similar. In this respect, indeed, it resembles agate, mother-of-pearl, and some other substances ; but it differs from all other bodies in possessing the extraordinary system of composite crystallization, in which an infinite number of crystals are disseminated equally in every possible azimuth, through a large crystalline plate ; having their axes all inclined at the same angle to that of the larger plate, and producing similar phenomena in every direction, and through every portion of the plate : or this remarkable structure may be otherwise described, by saying that the minute elementary crystals form the surfaces of an infinite number of cones, whose axes pass perpendicularly through every part of the larger plate.

An examination of the phenomena of iridescence afforded by this new substance, leads him to the conclusion that the iridescent films are formed at those times when the dash-wheel is at rest, during the night, and that they differ in their nature from the rest of the substance. These phenomena illustrate in a striking manner some ana-

logous appearances of incommunicable colours presented by mother-of-pearl, which had hitherto baffled all previous attempts to explain them; but which now appear to be produced by occasional intermissions in the process by which the material of the shell is secreted and deposited in the progress of its formation.

March 3, 1836.

The Rev. WILLIAM WHEWELL, M.A., Vice-President, in the Chair.

The Right Hon. the Earl of Minto and Joshua Field, Esq., were elected Fellows of the Society.

A paper was read, entitled, "Researches on the Tides. Fifth Series: On the Solar Inequality, and on the Diurnal Inequality of the Tides at Liverpool." By the Rev. William Whewell, F.R.S., Fellow of Trinity College, Cambridge.

The inequality both in the height and time of high water in the morning and evening tides of the same day, which varies according to a law depending on the time of the year, is termed by the author *the diurnal inequality*, because its cycle is one day. The existence of such an inequality has often been noticed by seamen and other observers; but its reality has only recently been confirmed by regular and measured observations; and its laws have never as yet been correctly laid down. The author gives an account of the observations now in progress at different ports, from which he expects they will be ascertained with great precision. He traces the correspondence of the observations of the diurnal inequality already made with the equilibrium theory; and remarks that the semi-diurnal tides, alternately greater and less, which are transmitted from the Southern Ocean to Liverpool, may be compared to the oscillations of a fluid mass: and that they are augmented by the action of the forces occurring at intervals equal to those of the oscillations. Hence the oscillations go on increasing for a considerable period after the forces have gone on diminishing, and reach their maximum a week after the forces have passed theirs.

The remaining sections of this paper are devoted to the investigation of the Solar inequalities at Liverpool. By carefully eliminating the Lunar effects, which the author is enabled to do by the aid of the preceding researches, he has determined the approximate circumstances of the Solar correction for the height. He has also obtained evidence of the existence, and some knowledge of the laws of the Solar inequalities of the times; and these inequalities, as thus discovered, are found to exhibit the same general agreement with the equilibrium theory which has been disclosed in all the inequalities hitherto detected. The results of the extensive observations now obtained are sufficiently precise to indicate the defects of our mathematical theories of hydrodynamics; and some of these are pointed out by the author, who remarks that although a short time ago the theory

was in advance of observation, at present observation is in advance of theory ; which mathematicians are therefore called upon to remodel and perfect.

The author proceeds to consider the effect of the Moon's declination on the Tides at Liverpool; which, as before observed, it is necessary to eliminate, in order to obtain the Solar inequality; and gives an explanation of various formulæ and tables constructed for that object. He then investigates the laws of the solar inequalities, first, as to the heights; and secondly, as to the times of high water at Liverpool, by applying to them these methods of calculation.

March 10, 1836.

FRANCIS BAILY, Esq., Vice-President, and Treas., in the Chair.

Edward John Johnson, Esq., Commander, R.N., was elected a Fellow of the Society.

"Report of Magnetic Experiments tried on board an Iron Steam-Vessel, by order of the Right Hon. the Lords Commissioners of the Admiralty." By Edward J. Johnson, Esq., Commander, R.N., accompanied by plans of the vessel, and tables showing the horizontal deflection of the Magnetic Needle at different positions on board, together with the dip and magnetic intensity observed at those positions, and compared with that obtained on shore with the same instruments. Communicated by Captain Beaufort, R.N., F.R.S., Hydrographer to the Admiralty; by command of the Right Hon. the Lords Commissioners of the Admiralty.

This report commences with a description of the iron steam-vessel, the "Garryowen," belonging to the City of Dublin Steam Packet Company, and built by the Messrs. Laird, of Liverpool. She is constructed of malleable iron, is 281 tons burthen, and draws only 5½ feet water, although the weight of iron in the hull, machinery, &c. is 180 tons.

This vessel was placed under the directions of the author, in Tarbert Bay, on the Shannon, on the 19th of October, 1835, for the purpose of investigating its local attractions on the compass. The methods which were adopted with that view are given ; together with tables of the results of the several experiments, and plans of the various parts of the Garryowen. The horizontal deflections of the magnetic needle at different situations in the vessel were observed, for the purpose of ascertaining the most advantageous place for a steering compass, and also for the application of Professor Barlow's correcting plate : and the dip and intensity in these situations were, at the same time, noted.

An experiment is detailed, showing that where several magnetic needles, freely suspended, were placed upon the quay, in Tarbert Bay, and the vessel warped from the anchorage towards them, first with her head in that direction and then with her stern, opposite deflections were produced : in the first case all the needles showing a

deviation to the eastward, and in the latter to the westward, of the true magnetic meridian.

Considering the height of the general mass of iron in the vessel and also that of the head and stern, together with the distance (169 feet) at which some of the needles indicated a deviation, the author concludes that the respective deflections were caused by the magnetic influence of the iron in the vessel; the combined effect of that about the bows representing the north pole of a magnet, and that about the stern a south pole. Hethen offers several suggestions for future observation on this subject, and connected with the little oxidation that is reported to have taken place in the vessel.

The experiments having been interrupted by a continuance of wet and stormy weather, the author proceeds to draw the following general practical conclusions, deduced from the series of observations already made, and points out the further experiments which he considers necessary to be tried.

1st. The ordinary place for a steering-compass on board ship is not a proper position for it in an iron steam-vessel.

2nd. The binnacle-compass in its usual place on board the Garryowen is too much in error to be depended upon.

3rd. In selecting a proper position for a steering-compass on board iron steam-vessels, attention should be paid to its being placed, as far as is practicable, not only above the general mass of iron, but also above any smaller portions of iron that may be in its vicinity; or such portions of iron should be removed altogether.

4th. The steering-compass should never be placed on a level with the ends either of horizontal or of perpendicular bars of iron.

5th. The extreme ends of an iron vessel are unfavourable positions, in consequence of magnetic influences exerted in those situations. The centre of the vessel is also very objectionable, owing to the connecting rods, shafts, and other parts of the machinery belonging to the steam-engine and wheels, which are in continual motion; independently of the influence exerted by the great iron tunnel in this part of the ship.

6th. No favourable results were obtained by placing the compass either below the deck, or on a stage over the stern.

7th. It was found that at a position $20\frac{1}{2}$ feet above the quarter-deck, and at another $13\frac{1}{2}$ feet above the same level, and about one seventh the length of the vessel from the stern, the deflections of the horizontal needle were less than those which have been observed in some of His Majesty's ships.

The author proceeds to point out various methods of determining, by means of a more extended inquiry, whether the position above indicated, or one nearer to the deck, is that at which the steering-compass would be most advantageously placed.

The concluding section contains an account of some observations made by the author on the effects of local attraction on board different steam-boats, from which it appears that the influence of this cause of deviation is more considerable than has been generally ima-

gined; and he points out several precautions which should be observed in placing compasses on board such vessels.

"Researches on the Integral Calculus. Part I." By Henry Fox Talbot, Esq., F.R.S.

The author premises a brief historical sketch of the progress of discovery in this branch of analytical science. He observes that the first inventors of the integral calculus obtained the exact integration of a certain number of formulæ only; resolving them into a finite number of terms, involving algebraic, circular, or logarithmic quantities, and developing the integrals of others into infinite series. The first great improvement in this department of analysis was made by Fagnani, about the year 1714, by the discovery of a method of rectifying the differences of two arcs of a given biquadratic parabola, whose equation is $x^4 = y$. He published, subsequently, a variety of important theorems respecting the division into equal parts of the arcs of the lemniscate, and respecting the ellipse and hyperbola; in both of which he showed how two arcs may be determined, of which the difference is a known straight line. Further discoveries in the algebraic integration of differential equations of the fourth degree were made by Euler; and the inquiry was greatly extended by Legendre, who examined and classified the properties of elliptic integrals, and presented the results of his researches in a luminous and well-arranged theory. In the year 1828, Mr. Abel, of Christiana, in Norway, published a remarkable theorem, which gives the sum of a series of integrals of a more general form, and extending to higher powers than those in Euler's theorem; and furnishes a multitude of solutions for each particular case of the problem. Legendre, though at an advanced age, devoted a large portion of time to the verification of this important theorem, the truth of which he established upon the basis of the most rigorous demonstration. M. Poisson has, in a recent memoir, considered various forms of integrals which are not comprehended in Abel's formula.

The problem, to the solution of which the author has devoted the present paper, is of a more general nature than that of Abel. The integrals, to which the theorem of the latter refers, are those comprised in the general expression $\int \frac{P dx}{\sqrt{R}}$ where P and R are entire polynomials in x . Next in order of succession to these, there naturally presents itself the class of integrals whose general expression is $\int \frac{P dx}{\sqrt[3]{R}}$, where the polynomial R is affected with a cubic, instead of a quadratic radical; but Abel's theorem has no reference to these, and consequently affords no assistance in their solution. The same may be said of every succeeding class of integrals affected with roots of higher powers. Still less does the theorem enable us to find the sum of such integrals as $\int \phi(R) dx$; R being, as before, any entire polynomial (that is, containing at least two different powers of x),

and ϕ being any function whatever. The author then details the processes by which he arrives at the solution of this latter problem.

March 17, 1836.

Sir JOHN RENNIE, Knt., Vice-President, in the Chair.

Major T. Seymour Burt, Bengal Engineers, was elected a Fellow of the Society.

A paper was read, "On the reciprocal attractions of positive and negative electric Currents, whereby the motion of each is alternately accelerated and retarded." By P. Cunningham, Esq., Surgeon R.N. Communicated by Alexander Copland Hutchison, Esq., F.R.S.

The author found that a square plate of copper, six inches in diameter, placed vertically in the plane of the magnetic meridian, and connected with a voltaic battery by means of wires soldered to the middle of two opposite sides of the plate, exhibited magnetic polarities on its two surfaces, indicative of the passage of transverse and spiral electrical currents, at right angles to the straight line joining the ends of the wires. The polarities were of opposite kinds on each side of this middle line, in each surface; and were reversed on the other surface of the plate. The intensities of these polarities at every point of the surface were greatest the greater its distance from the middle line, where the plate exhibited no magnetic action. The author infers from this and other experiments of a similar kind, that each electric current is subject, during its transverse motion, to alternations of acceleration and retardation, the positive current on the one side of the plate and the negative on the other, by their reciprocal attractions, progressively accelerating each other's motions, as they approach, in opposite directions, the edge round which they have to turn. After turning round the edge their motion will, he conceives, be checked by coming in contact with the accelerated portions of the opposing currents to which they respectively owed their former increase of velocity; so that the one current will be retarded at the part of the plate where the other is accelerated. To these alternate accelerations and retardations of electric currents during their progressive motion, the author is disposed to refer the alternate dark and luminous divisions in a platina wire heated by electricity, as was observed by Dr. Barker.

"Meteorological Journal kept at Allenheads, near Hexham." By the Rev. William Walton. Communicated in a letter to P. M. Roget, M.D., Sec. R.S.

This Journal contains a register of the height of the barometer, taken at 9 A.M. and at 3 P.M. during every day in January and February 1836, with remarks on the state of the weather during a few particular days. The station where the observations were made is elevated 1400 feet above the level of the sea.

March 24, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

Richard Beamish, Esq., was elected a Fellow of the Society.

A paper was in part read, entitled "On the Temperatures and Geological Relations of certain Hot Springs; particularly those of the Pyrenees; and on the Verification of Thermometers." By James David Forbes, Esq., F.R.S., Professor of Natural Philosophy in the University of Edinburgh.

The Society then adjourned over the Easter vacation, to meet again on the 14th of April next.

April 14, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

The reading of Professor Forbes's paper, "On the Temperatures and Geological Relations of certain Hot Springs; particularly those of the Pyrenees; and on the Verification of Thermometers," was resumed and concluded.

The author expresses his regret that notwithstanding the great interest, more especially in a geological point of view, which attaches to every topic connected with the origin, the nature, and the permanence in temperature of the many thermal springs met with in different parts of the world, our information on these subjects is exceedingly deficient. On many points which might easily be verified, and which are of essential consequence towards obtaining a satisfactory theory of the phenomena, we as yet possess but vague and uncertain knowledge. It is evident that the first step towards the establishment of such a theory must consist in the precise determination of the actual temperature of each spring; from which we may derive the means of estimating by comparative observations, at different periods, the progressive variations, whether secular, monthly, or even diurnal, to which that temperature is subject. We have at present, indeed, not only to lament the total absence of exact data on which to found such an inquiry; but we are obliged to confess that, owing to the difficulties which meet us even in the threshold, we have not, even at the present day, made any preparation for establishing the basis of future investigation, by applying such methods of experiment as are really in our power, and are commensurate with the superior accuracy of modern science. The researches of Fourier would lead us to the conclusion that, if the high temperature of these springs be derived solely from that of the interior portions of the earth, the changes which can have occurred in that temperature, during any period to which history extends, must be so minute as to be inappreciable. On the other hand, the theory of internal chemical changes, which have been assigned as the origin of volcanos, would suggest it as improbable that this temperature has remained constantly the

same; and as a more likely occurrence, even were we to suppose that no uniform secular diminution took place, that it would be liable to occasional irregular fluctuations. The influence of earthquakes on the temperature of hot springs is also admitted; and it would be very desirable to learn, from a series of consecutive observations, whether abrupt changes, similar to those which have occasionally been noticed, are not of frequent occurrence.

The author has diligently laboured to collect, by observations made on the spot, materials for supplying this great chasm in the natural history of our globe. As an essential preliminary means of obtaining accurate results, he applied himself to the verification of the scales of the thermometers he employed in these researches: and he describes, in a separate section of this paper, the methods which he adopted for the attainment of this object. He first fixed with great precision the standard points of each thermometer, namely the freezing and boiling temperatures of water, by a mode which he specifies: and afterwards determined the intermediate points of the scale by a method, similar to that of Bessel; namely, that of causing a detached column of mercury to traverse the tube; but simpler in practice. Instead of employing for that purpose columns of mercury of arbitrary length, and deducing by a complex and tentative process the portions of the tube having equal capacities, the author detaches a column of mercury from the rest, of such a length as may be nearly an aliquot part of the length of the scale for 180° ; and causes this column to step along the tube; the lower part of the column being brought successively to the exact points which the upper extremity had previously occupied: so that, at last, if its length has been properly chosen, the upper end of the column is found to coincide with the end of the scale: and this being accomplished, it is easy to apply to every part of the actual scale of the instrument the proper corrections, which may, for greater practical convenience, be drawn up in the form of a table.

In the next section, the author gives a detailed account of his observations of the mineral springs of the Pyrenees, made during the months of July and August, 1835, following them in their natural order from west to east, and describing their geological positions, the special circumstances of interest relating to them, and their actual temperatures.

In the third and last section he extends his inquiries to the hot springs met with in some other parts of Europe; and in particular, those of the baths of Mont d'Or and of Bourboule, in France; of Baden-Baden, in Germany; of Loèche, or Leuk, in the Vallais; of Pfeffers, in the canton of St. Gall, in Switzerland; and the baths of Nero, near Naples. The final results of all the observations contained in this paper are presented in the form of a table, with comparative columns of those derived from some unpublished observations of M. Arago, and of those of M. Anglada.

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No. 25.

April 21, 1836.

RODERICK IMPEY MURCHISON, Esq., Vice-President, in the Chair.

A paper was read, entitled "Additional Observations on Voltaic Combinations." In a letter addressed to Michael Faraday, Esq., D.C.L., F.R.S. Fullerian Professor of Chemistry in the Royal Institution, &c. By J. Frederick Daniell, Esq., F.R.S., Professor of Chemistry in King's College, London.

The author has found that the constant battery, of which he described the construction in a former communication to the Royal Society, might be rendered not only perfectly steady in its action, but also very powerful; as well as extremely efficacious and convenient for all the purposes to which the common voltaic battery is usually applied. With this view he places the cells which form the battery in two parallel rows, consisting of ten cells in each row, on a long table, with their siphon-tubes arranged opposite to each other, and hanging over a small gutter, placed between the rows, in order to carry off the refuse solution when it is necessary to change the acid. Having observed that the uniformity of action may be completely maintained by the occasional addition of a small quantity of acid, he is able to dispense with the cumbrous addition of the dripping funnel; an arrangement which admits with facility of any combination of the plates which may be desired.

April 28, 1836.

DAVIES GILBERT, Esq., Vice-President, in the Chair.

Captain John James Chapman, R.A., was elected a Fellow of the Society.

On certain parts of the Theory of Railways; with an investigation of the formulæ necessary for the determination of the resistances to the motion of carriages upon them, and of the power necessary to work them. By the Rev. Dionysius Lardner, LL.D., F.R.S.

The author observes, in his prefatory remarks, that an extensive and interesting field of mathematical investigation has been recently opened in the mechanical circumstances relative to the motion of heavy bodies on railways; and having collected a body of experiments and observations sufficient to form the basis of a theory, he purposes,

in the present paper, to lay before the Society a series of mathematical formulæ, embodying the most general expressions for the phenomena of the motion of carriages on these roads.

The author begins by investigating the analytical formulæ for the traction of trains over a level line which is perfectly straight, and finds, first, the distance and time within which, with a given amount of tractive power, the requisite speed may be obtained at starting; and also the point where the tractive power must be suspended, previous to coming to rest. The excess of tractive power necessary to get up the requisite speed is shown to be equal to the saving of tractive power previous to a stoppage; and formulæ are given for the determination of the time lost under any given conditions at each stop.

The motion of trains in ascending inclined planes which are straight, is next considered; and formulæ are given combining the effects of friction and gravity, in opposition to the tractive force. The circumstances which affect every change of speed, and the excess of tractive force necessary, in such cases, to maintain the requisite speed, are determined; as well as the other circumstances already stated with respect to level planes.

The friction of trains upon descending planes is next investigated; and an important distinction is shown to exist between two classes of planes; viz., those whose acclivities are inferior to the angle of repose, and those of more steep acclivities. A remarkable relation is shown to exist between the tractive forces in ascending and descending the first class of planes. For descending planes of greater acclivity than the angle of repose, the use of breaks becomes essentially requisite. The effect of these contrivances is investigated, as well as the motion of trains on the accidental failure of breaks.

In any attempts which have been hitherto made to obtain the actual velocities acquired by trains of carriages or waggons under these circumstances, an error has been committed which invalidates the precision of the results; the carriages having been treated as sledges moving down an inclined plane. The author has here given the analytical formulæ by which the effect of the rotatory motion of the wheels may be brought into computation; this effect, depending obviously on the amount of inertia of the wheels, and on the proportion which their weight bears to the weight of the waggon.

The properties investigated in this first division of the paper, are strictly those which depend on the longitudinal section of the line, presumed to be straight in every part of its direction. There is, however, another class of important resistances which depend on the ground-plan of the road, and these the author next proceeds to determine.

The author then gives the analytical formulæ which express the resistance arising,—*first*, from the inequality of the spaces over which the wheels, fixed on the same axle, simultaneously move; *secondly*, from the effort of the flanges of the wheels to change the direction of the train; and *thirdly*, from the centrifugal force pressing the flange against the side of the rail. He also gives the formulæ necessary to determine, in each case, the actual amount of pressure produced by

a given velocity and a given load, and investigates the extent to which these resistances may be modified by laying the outer rail of the curve higher than the inner. He assigns a formula for the determination of the height which must be given to the outer rail, in order to remove as far as possible all retardation from these causes; which formula is a function of the speed of the train, the radius of the curve, and the distance between the rails.

In the latter part of the paper, the author investigates the method of estimating the actual amount of mechanical power necessary to work a railway, the longitudinal section and ground-plan of which are given. In the course of this investigation he arrives at several conclusions, which, though unexpected, are such as necessarily arise out of the mechanical conditions of the inquiry. The first of these is, that all straight inclined planes of a less acclivity than the angle of repose, may be mechanically considered equivalent to a level, provided the tractive power is one which is capable of increasing and diminishing its energy, within given limits, without loss of effect. It appears, however, that this condition does not extend to planes of greater acclivities than the angle of repose; because the excess of power required in their ascent is greater than all the power that could be saved in their descent; unless the effect of accelerated motion in giving momentum to the train could properly be taken into account. In practice, however, this acceleration cannot be permitted; and the uniformity of the motion of the trains in descending such acclivities must be preserved by the operation of the break. Such planes are therefore, in practice, always attended with a direct loss of power.

In the investigation of the formulæ expressive of the actual amount of mechanical power absorbed in passing round a curve, it is found that this amount of power is altogether independent of the radius of the curve, and depends only on the value of the angle by which the direction of the line on the ground-plan is changed. This result, which was likewise unexpected, is nevertheless a sufficiently obvious consequence of the mechanical conditions of the question. If a given change of direction in the road be made by a curve of large radius, the length of the curve will be proportionably great; and although the intensity of the resistance to the tractive power, at any point of the curve, will be small in the same proportion as the radius is great, yet the space through which that resistance acts will be great in proportion to the radius: these two effects counteract each other; and the result is, that the total absorption of power is the same. On the other hand, if the turn be made by a curve of short radius, the curve itself will be proportionately short; but the intensity of the resistance will be proportionately great. In this case, a great resistance acts through a short space, and produces an absorption of power to the same extent as before.

In conclusion, the author arrives at one general and comprehensive formula for the actual amount of mechanical power necessary to work the line in both directions; involving terms expressive, *first*, of the ordinary friction of the road; *secondly*, of the effect of inclined planes, or *gradients*, as they have been latterly called; and, *thirdly*, of the

effect of curves involving changes of direction of the road, the velocity of the transit, and the distance between the rails ; but, for the reason already stated, not comprising the radii of the curves.

Although the radii of the curves do not form a constant element of the estimate of the mechanical power necessary to work the road, nevertheless they are of material consequence, as far as regards the safety of the transit. Although a short curve with a great resistance may be moved over with the same expenditure of mechanical power as a long curve with a long radius, yet, owing to the intensity of the pressure of the flange against the rail, the danger of the trains running off the road is increased : hence, although sharp curves cannot be objected to on the score of loss of power, they are yet highly objectionable on the score of danger.

In the present paper, the author has confined himself to the analytical formulæ expressing various mechanical effects of the most general kind ; the coefficients and constants being expressed merely by algebraical symbols : but he states that he has made an extensive series of experiments within the last few years, and has also procured the results of experiments made by others, with a view to determine the mean values of the various constants in the formulæ investigated in this paper. He has also, with the same view, made numerous observations in the ordinary course of transit on railways ; and he announces his intention of soon laying before the Society, in another paper, the details of these experiments, and the determination of the mean values of these various constants, without which the present investigation would be attended with little practical knowledge.

A paper was also read, entitled " Register of the State of the Barometer and Thermometer kept at Tunis, during the years 1829, 1830, 1831 and 1832." Presented by Sir Thomas Reade, His Majesty's Agent and Consul General at Tunis. Communicated by P. M. Roget, M.D., Sec. R.S.

The observations here registered are those of the thermometer at 9 A.M., at noon, and at 6 P.M., and the points of the wind, and height of the barometer for each day of the abovementioned years.

May 5, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

Edward Burton, Esq., William Sands Cox, Esq., and Captain Thomas Locke Lewis, R.E., were elected Fellows of the Society.

A paper was in part read, entitled " On the Optical Phenomena of certain Crystals." By Henry Fox Talbot, Esq., F.R.S.

May 12, 1836.

The Rev. WILLIAM WHEWELL, M.A., Vice-President, in the Chair.

The reading of a paper, entitled " On the Optical Phenomena of

certain Crystals," by Henry Fox Talbot, Esq., F.R.S., was resumed and concluded.

In this memoir the author gives an account of the optical properties of certain minute crystals, obtained by the evaporation of a solution of borax in phosphoric acid, exhibited when they are examined by means of the polarizing microscope. The field of view is then seen covered with minute circular spots, each composed of a close assemblage of delicate acicular crystals, radiating from the centre; together with other circular bodies, in which this disposition is not observable, on account of the close union of the component crystals, which, producing optical contact, gives perfect transparency to the whole mass. When the field of view is rendered dark by the rectangular crossing of the polarizing laminae, each of these little circles becomes luminous, and exhibits a well-defined dark cross, dividing its area into four equal sectors. These crosses have a similar position in all the circles; and their direction remains unaltered when the crystals are turned round in their own plane, by causing the plate of glass, on which they are placed, to revolve.

On examining the larger circles with a high magnifying power, and under favourable circumstances of illumination, the author observed upon each a series of coloured concentric rings: but the number as well as the colour of these rings varies in different crystals. The innermost ring is deeply coloured, or black; and incloses a central space of white light, which is traversed by the arms of the cross, intersecting in the centre. This part of the cross, which stands within the innermost ring, is beautifully defined, and perfectly black. The whole system of phenomena are exactly analogous to that exhibited by uniaxal crystals; and corresponds still more closely with those discovered by Sir David Brewster in spheres of glass, the density of which had been rendered variable from the centre to the surface by immersion in heated oil; excepting that the microscopic crystals here described are possessed of a far more intense polarizing energy. The author thinks it probable that the phenomena are in both cases produced by similar conditions of density; which, in a circular mass formed by the aggregation of needle-shaped crystals radiating from a common centre, it is natural to suppose would rapidly increase from the circumference to the centre. By watching the progress of crystallization he ascertained that this was, in fact, the mode in which the crystals are constructed: for they frequently appeared, at first, in the form of lengthened prisms, which subdivided themselves at both ends into an immense multitude of divergent fibres, like those of a brush; apparently repelling each other as they extended in length, and occupying spaces corresponding to two opposite sectors of a circle; until, by spreading still farther in breadth, their edges united, and filled the whole of a circular area. In all the stages of this process, the formation of the black cross may be seen to keep pace with the developement of the crystal, until perfectly displayed on the completion of the crystalline structure. The author notices the analogy which this structure presents with that of the crystalline lens of the cod fish, as has been lately described by Sir David Brewster; and

also the remarkable correspondence existing between the optical properties resulting from this structure, and the phenomena of the circular polarization of fluids, which have been accounted for by the existence of molecules of a structure nearly similar.

The author proceeds to examine the action of these crystals in common, or unpolarized light; and concludes from his inquiries that each of their diameters polarized the light in the plane passing through itself and the direction of the ray; so that the whole emergent light consists of equal portions polarized in every plane, and according to every diameter of the circle. This action is similar to that which would be exerted by an assemblage of an infinite number of pieces of tourmaline cut into the form of infinitely small sectors, in the direction of the axis, and disposed as radii in a circle. The author considers it probable that the tourmaline itself is an aggregate of acicular crystals of this description, disposed in a direction parallel to its axis, and being in optical contact, as well as in perfect mechanical cohesion.

In a postscript to this paper, an account is given of a new species of Dichroism in crystals, to the discovery of which the author was led by applying to them his peculiar method of observation with polarized light. In these experiments the crystals themselves perform the office of the analysing plate, acting on light previously polarized, and transmitted through a plate of mica. Under these circumstances, the crystals of borax, described in the first part of the paper, when examined with a lens of moderate power, appear beautifully coloured with two complementary colours, according to the position of their axes. These experiments tend to confirm the views of Sir David Brewster and others as to the general cause of the dichroism of crystals, which is ascribed to a difference of absorptive energy in different directions with relation to their axes; arising from a difference of elasticity in these respective directions.

May 19, 1836.

RODERICK IMPEY MURCHISON, Esq., Vice-President,
in the Chair.

A paper was read, entitled, "On the valuation of the mechanical effect of Gradients on a line of Railroad." By Peter Barlow, Esq., F.R.S.

The exact amount of the influence of ascents and descents occurring in the line of a railway on the motion of a load drawn by a locomotive engine having been differently estimated by different persons, the author was induced to investigate the subject. A few observations are premised on the erroneous assumptions which, he conceives, have in general vitiated the results hitherto deduced. The first of these is that the expenditure of power requisite for motion is equal to the resistance to traction; whereas it must always greatly exceed it. No account, he remarks, has been taken of the pressure of the atmosphere on the piston, which the force of the steam has to overcome before it can be available as a moving power. Another source of error has been that

the statical and dynamical effects of friction have been confounded together ; whereas they are the same in amount only when the body is put in motion by gravity ; but not when it is urged down an inclined plane by an extraneous force. In the latter case these effects are no longer comparable ; friction being a force which, in an infinitely small time, is proportional to the velocity, while that of gravity is constant at all velocities ; or, in other words, the retardation from friction is proportional to the space described, while that from gravity has reference only to the time of acting, whatever space the body may pass over in that time. It is an error to assume that the mechanical power of the plane is equivalent to a reduction of so much friction ; for the friction down the inclined plane is the same as on a horizontal plane of the same length, rejecting the trifling difference of pressure ; and the whole retardation in passing over the plane, or the whole force required to overcome it, is the same at all velocities, and by whatever force the motion is produced ; but the assisting force from gravity is quite independent of the space or of the velocity.

In the investigations which the author has prosecuted in this paper, he assumes that equal quantities of steam are produced in the same time at all velocities ; and he adopts for his other data, those given by Mr. Pambour in his *Treatise of Locomotive Engines*. He deduces a formula from which, the speed on a level being given, we may compute the relative and absolute times of a train ascending a plane ; and consequently also the ratio of the forces expended in the two cases ; or the length of an equivalent horizontal plane ; that is, of one which will require the same time and power to be passed over by the locomotive engine as the ascending plane.

The next objects of inquiry relate to the descent of trains on an inclined plane, and comprise two cases : the first, that when the power of the engine is continued without abatement ; and the second, that when the steam is wholly excluded, and the train is urged in its descent by gravity alone. The author arrives at the conclusions, that in the first of these cases, when the declivity is one in 139, the velocity, on becoming uniform, will be double that in a horizontal plane : and that for a declivity of one in 695, the uniform velocity of descent will be one fifth greater than on the horizontal plane ; and this, he observes, is perhaps the greatest additional velocity which it would be prudent to admit. A plane of one in 695 is therefore the steepest declivity that ought to be descended with the steam-valve fully open ; all planes with a declivity between this and that of one in 139 require to have the admission of steam regulated so as to modify the speed, and adjust it to considerations of safety ; and lastly, all planes of a greater slope than this last require, in descending them, the application of the brake.

A paper was also read, entitled, " On the application of Glass as a substitute for metal balance-springs in Chronometers." By Messrs. Arnold and Dent. Communicated by Francis Beaufort, Esq., Captain R.N., F.R.S., Hydrographer to the Admiralty.

In their endeavours to determine and reduce the errors arising from

the expansions of the balance-spring of chronometers consequent on variations of temperature, the authors came to the conclusion that there exist certain physical defects in the substances employed for its construction, beyond the most perfect mechanical form that can be given to it, which interfere with the regularity of its agency : so that however exquisite may be its workmanship, and however complete its power of maintaining a perfect figure when in different degrees of tension, yet the imperfect distribution of its component parts may give rise to great incorrectness in its performance. Hence the balance-spring not only should be made of a substance most highly elastic, but its elasticity should not be given to it by any mechanical or chemical process : as a body in motion, it should be the lightest possible ; and, as far as the case admits of, it should be free from atmospheric influence. Glass suggested itself as the only material possessing, in the greatest degree, all these desirable properties. Its fragility, although apparently a great objection to its employment, was found, on trial, to constitute no obstacle whatever ; for it was found to possess a greater elastic force than steel itself, and thus to admit of greater amplitude in the arc of vibration.

It was first proposed to ascertain how far a glass balance-spring would sustain low temperatures ; and it was found by experiment that it resisted completely the effects of a cold as great as that of $+12^{\circ}$ of Fahrenheit's thermometer ; thus satisfactorily removing any objection which might be brought against its use from its supposed fragility in these low temperatures. The next object of solicitude was to determine whether it would withstand the shock arising from the discharge of cannon in the vicinity ; and its power of resisting concussions of this nature was fully established by experiments made with this view on board H.M.S. Excellent at Portsmouth.

On comparing the performance of glass balance-springs with metallic ones, when the temperatures were raised from 32° to 100° , it was found that while the loss in twenty-four hours in the gold spring was $8^m 4^s$, that of steel $6^m 25^s$, and that of palladium $2^m 31^s$, that of a glass spring was only 40^s . These differences the authors ascribe principally to the different degrees in which the substances had their elasticity reduced by an increase of temperature. As glass was thus found to suffer a much smaller loss of elasticity by this cause than metals, they proceeded to construct a glass balance suited to the correction of the small error still occasioned by this cause, employing a glass disc for this purpose. The compensation being completed, they next tested the isochronism of the glass spring, and it proved to be as perfect as any metallic spring. Chronometers thus constructed are now in course of trial at the Royal Observatory. In common with all other instruments of the same kind they have shown a disposition to progressive acceleration, the cause of which is but little known, but which appears to be influenced by the action of the air.

The Society then adjourned over the Whitsun week, to meet again on the second of June next.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1836.

No. 26.

June 2, 1836.

DAVIES GILBERT, Esq., V.P., in the Chair.

A paper was read, entitled "Note relative to the supposed origin of the deficient rays in the Solar Spectrum; being an account of an experiment made at Edinburgh during the Annular Eclipse of May 15, 1836." By James D. Forbes, Esq., Professor of Natural Philosophy in the University of Edinburgh.

The observation that some of the rays of light, artificially produced, are absorbed by transmission through nitrous acid gas, had suggested to Sir David Brewster the idea that the dark spaces in the solar prismatic spectrum may, in like manner, be occasioned by the absorption of the deficient rays during their passage through the sun's atmosphere. It occurred to the author that the annular eclipse of the sun of the present year would afford him an opportunity of ascertaining whether any difference in the appearance of the spectrum could be detected when the light came from different parts of the solar disc, and had consequently traversed portions of the sun's atmosphere of very different thickness; and that accurate observations of this kind would put the hypothesis in question to a satisfactory test. The result of the experiment was that no such differences could be perceived; thus proving, as the author conceives, that the sun's atmosphere is in no way concerned with the production of the singular phenomenon of the existence of dark lines in the solar spectrum.

A paper was also read, entitled "On the connexion of the anterior columns of the Spinal Cord with the Cerebellum; illustrated by preparations of these parts in the Human subject, the Horse, and the Sheep." By Samuel Solly, Esq., Lecturer on Anatomy and Physiology at St. Thomas's Hospital, M.R.I., Fellow of the Royal Medical and Chirurgical Society, and Member of the Hunterian Society. Communicated by P. M. Roget, M.D., Sec. R.S.

The exact line of demarcation between the tracts of nervous matter, subservient to motion and to sensation, which compose the spinal cord, has not yet been clearly determined. The proofs which exist of a power residing in the cerebellum which regulates and controls the

actions of muscles, would lead us to suppose that the fibres of the motor nerves are continuous with those of the cerebellum; but hitherto no observations have been made which prove the existence of this connexion; and it is the object of the author, in this paper, to establish, by a more careful examination of the anatomical structure of this part of the nervous system, such continuity of fibres between the anterior columns of the spinal cord and the cerebellum. The corpora pyramidalia have been hitherto considered as formed by the entire mass of the anterior, or motor columns of the spinal cord; but the author shows that not more than one half of the anterior columns enters into the composition of these bodies: and that another portion, which he terms the *antero-lateral* column, when traced on each side in its progress upwards, is found to cross the cord below the corpora olivaria, forming, after mutual decussation, the surface of the corpora restiformia; and ultimately being continuous with the cerebellum. These fibres are particularly distinct in the medulla oblongata of the sheep and of the horse. The author conceives that the office of the antero-lateral columns is to minister to the involuntary, as well as to the voluntary movements: that the facial nerve arises from both the voluntary and involuntary tracts; and that the pneumogastric nerve arises both from the involuntary and the sensory tracts.

June 9, 1836.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

“Di-cussion of the Magnetical Observations made by Captain Back, R.N., during his late Arctic Expedition. By Samuel Hunter Christie, Esq., M.A., F.R.S.

The author, having been consulted by Captain Back, previous to the departure of the latter, in 1833, with the expedition for the relief of Captain Ross, respecting the nature of the magnetical observations which it might be desirable to make in the regions he was about to visit, and considering that, with a view to the attainment of the principal object of the expedition, the greatest economy of time in making these observations was of the first importance, limited his suggestions, in the first instance, to the methods proper to be employed for determining the direction and the dip of the needle, but more especially the latter. Captain Back, immediately on his return, placed all his magnetical observations at the disposal of Mr. Christie, who having since completed their reduction, gives, in the present paper, the results of his labours.

The first part of the paper relates to the observations of the Dip of the magnetic needle. With a view to economize as much as possible the time consumed in making each observation, the process of inverting the poles of the needle, which is usually resorted to in each instance, was here dispensed with. But in order that the dip may be determined independently of this operation, it is necessary not only that the position of the centre of gravity of the needle employed should be ascertained, but that it should be permanent. In giving an account of the observations made to verify this condition, the author com-

mences with those at Fort Reliance, which was the first winter station of the expedition; and where the dip was determined by observations of the needle, both with direct and also with inverted poles. The author then enters upon an investigation of formulæ for the determination of the dip by means of a needle, in which the value of a certain angle, denoted by the symbol γ , determining the position of the centre of gravity, has been ascertained; and, conversely, for the determination of the value of the same angle, or, which is equivalent to it, the position of the centre of gravity of the needle, when the dip at the place of observation is given. He next inquires whether any tests can be applied to the observations under discussion, which may indicate the extent of the errors by which the results deduced from them may be affected; and he employs for this purpose the values of the terrestrial magnetic intensity furnished by certain equations obtained in the preceding investigation; making the proper allowances, first, for the needles used being ill adapted to this method of determining the relative intensities; secondly, for errors of observation in determining the times of vibration of the needle; and thirdly, for disturbing causes which might affect the observations. Considerable differences were found to exist in the results obtained by the two methods, at New York, Montreal, Fort Alexander, Montreal Island, and Fort Ogle; differences which can be accounted for only by errors in the assumed magnitude of the angle γ , and which, consequently, indicate the want of permanence in that angle. It was necessary, therefore, to inquire what changes in the angle γ will account for these discrepancies, and how far the value of the dip, thus obtained, may be affected by them. Formulæ are then deduced by which these changes may be determined.

From a comparison of the observed and computed values of the angles involved in these investigations, the author infers that the differences between those of one of these angles are, with a few exceptions, contained within the limits of the errors incident to dip observations: but with respect to the other angle, they in general exceed those limits. Upon the whole, he concludes that the discrepancies which appear between the values of the terrestrial intensity, as deduced from the times of vibration of the needle, and from the observed angles of inclination to the horizon, are principally attributable to a want of absolute permanence in its axis of motion. In the present case, the centre of gravity of the needle being nearly coincident with the axis, a very minute derangement in that axis would cause a considerable change in the value of the angle γ ; so that the existence of differences in the values of this angle do not warrant the inference that the needle itself received any serious injury during the expedition; to which, indeed, from the care taken of it by Captain Back, it could not well have been liable.

The second part of the paper relates to the observations of the variation of the magnetic needle, which are already published in Capt. Back's narrative, and which are here introduced for the purpose of applying them, in conjunction with the observations of the dip, detailed

in the preceding part, to a formula deduced from theory, with the view of ascertaining how far they may tend to support that theory.

The third section is devoted to the comparison of the observations of the dip and variation of the needle with theoretical results of a more general kind. The observations made by Captain Back are peculiarly adapted for verifying the hypotheses on which the theories of terrestrial magnetism rest, and that theory, in particular, which assumes the existence of two magnetic poles, symmetrically situated in a diameter of the earth, and near to its centre: for, on this hypothesis, the poles of verticity and of convergence will coincide; and the tangent of the dip will be equal to twice the tangent of the magnetic latitude. In no case has a progress towards the magnetic pole been made so directly, and to such an extent, as in the present expedition; whether that point be considered as the point of convergence of magnetic meridians, or that at which the direction of the force is vertical. It is deducible from the theory that the product of the tangent of the dip by the tangent of the polar distance is equal to two: and therefore, if the distance of the pole of convergence from two stations be determined by means of the observed variations at those stations, we may estimate, by the approximation of this product to the number two, in each case, the degree of coincidence which exists between theory and observation. A table is then given, exhibiting the several data on which this comparison is made, and the results deduced from them. From an inspection of the numbers in the column which indicate the deviations from theory it appears that there is not, in general, that accordance between the observations and the theory which might reasonably have been expected; and that although that theory may serve as a first approximation, yet it requires to be considerably modified to reconcile it with the observations. Hence the author arrives at the general conclusion that, unless considerable errors have crept into the observations of either the dip or the variation, the theoretical pole of verticity does not coincide with the pole of convergence, even when the positions of these points are deduced from observations made at very limited distances from those poles.

“On the Safety-valve of the right Ventricle of the Heart in Man; and on the gradations of the same apparatus in Mammalia and Birds.”
By J. W. King, Esq. Communicated by Thomas Bell, Esq., F.R.S.

In this paper additional evidence is given by the author in corroboration of the principles which he had announced in a former communication, which was read to the Royal Society in May 1835, on the influence of the tricuspid valve of the heart on the circulation of the blood. His object is to demonstrate that the tricuspid valve in man occasionally serves the purpose of a safety-valve, being constructed so as to allow of the reflux of the blood from the ventricle into the auricle, during the varying states of distension to which the right cavities of the heart are at times subjected; that a similar function is maintained in the greater number of animals possessing a double circulation, and also that in the different orders of these animals the structure of this

valve is expressly adapted to the production of an effect of this kind, in various degrees, corresponding with the respective characters and habits of each tribe. He is thus led to conclude that the function which the tricuspid valve exercises exhibits, in the extent of its development, a regular gradation, when followed throughout the different orders of Mammalia and Birds; and that it extends even to some Reptiles.

The force with which the circulating blood is impelled by the general venous trunks into the heart, and which is dependent on the action of the arterial system, the degree of compression arising from muscular action, combined with the resistance of the valves of the veins, and is also influenced by occasional accumulations of blood from rapid absorption, from impeded respiration, and from cold applied to the surface of the body, is shown to be subject to great and sudden variations. Any increase taking place in this force tends to produce distension of the right ventricle of the heart, followed by disturbance in the valvular action of the tricuspid membrane, owing to the displacement of its parts, which thus allows of a considerable reflux of blood into the auricle. Among the Mammalia, the lowest degree of this action, corresponding to that of a safety-valve, is found in the rodent, the marsupial, and the canine tribes. The next in degree is that which occurs in the order of Edentata and the feline genus. The *Quadrumanæ* occupy the next place in the scale of gradation. The human conformation exhibits this function in a very conspicuous manner, especially in the adult period; for at birth, when the right ventricle is unyielding, it scarcely exists; and in various states of disease the tricuspid valve acts with too much or with too little efficacy. The *Pachydermata* and *Ruminantia* come next in succession. The Seal exhibits this peculiarity in a still higher degree; but in no order of Mammalia does it exist to so great an extent as in the *Cetacea*, which appear, indeed, to possess a peculiar additional provision for effectually securing the permanent performance of this office, which the author compares to that of a safety-valve. A similar function, subject to similar gradations, is likewise traced in different orders of Birds. It is but slight in the *Gallinacæ*; and rather greater in the *predaceous* tribes. In some of the *Waders* it exists to a considerable extent; but is greatest of all in the orders of *Passerinæ* and *Scanzores*. Crocodiles and the *Ornithorhynchus* present some traces of this peculiar provision relatively to the circulation.

“Some Account of the appearances of the Solar Spots, as seen from Hereford, on the 15th and 16th of May, 1836, during and after the Solar Eclipse.” By Henry Lawson, Esq., in a Letter to Sir Henry Ellis, K.G.H., F.R.S., by whom it was communicated to the Society.

The spots on the sun's disc, at the period referred to, were very numerous; and one of great size, being many thousand miles in diameter, in particular attracted attention, from its penumbra presenting an appearance similar to a sky filled with small flocculent white clouds, perfectly distinct from one another; while on two sides were seen

large masses of darker clouds, which seemed as if pouring their substance into the central chasm. The figure of the solar spots did not undergo any perceptible change of form during the progressive passage of the edge of the moon over them.

“On the Brain of the Negro, compared with that of the European and the Ourang-Outang.” By Frederick Tiedemann, M.D., Professor of Anatomy and Physiology in the University of Heidelberg, and Foreign Member of the Royal Society.

It has long been the prevailing opinion among naturalists that the Negro race is inferior, both in organization and in intellectual powers, to the European; and that, in all the points of difference, it exhibits an approach to the Monkey tribes. The object of the present paper is to institute a rigid inquiry into the validity of this opinion. The author has, for this purpose, examined an immense number of brains of persons of different sexes, of various ages, and belonging to different varieties of the human race, both by ascertaining their exact weight, and also by accurate measurement of the capacity of the cavity of the cranium; and has arrived at the following conclusions. The weight of the brain of an adult male European varies from 3lbs. 3oz. to 4lbs. 11 oz. troy weight: that of the female weighs, on an average, from 4 to 8 oz. less than that of the male. The brain usually attains its full dimensions at the age of seven or eight; and decreases in size in old age. At the time of birth, the brain bears a larger proportion to the size of the body than at any subsequent period of life, being then as one sixth of the total weight; at two years of age it is one fourteenth; at three, one eighteenth; at fifteen, one twenty-fourth; and in the adult period, that is, from the age of twenty to that of seventy, it is generally within the limits of one thirty-fifth and one forty-fifth. In the case of adults, however, this proportion is much regulated by the condition of the body as to corpulence; being in thin persons from one twenty-second to one twenty-seventh, and in fat persons often only one fiftieth, or even one hundredth of the total weight of the body. The brain has been found to be particularly large in some individuals possessed of extraordinary mental capacity. No perceptible difference exists either in the average weight or the average size of the brain of the Negro and of the European: and the nerves are not larger, relatively to the size of the brain, in the former than in the latter. In the external form of the brain of the Negro a very slight difference only can be traced from that of the European; but there is absolutely no difference whatsoever in its internal structure, nor does the Negro brain exhibit any greater resemblance to that of the ourang-outang than the brain of the European, excepting, perhaps, in the more symmetrical disposition of its convolutions.

Many of the results which the author has thus deduced from his researches are at variance with the received opinions relative to the presumed inferiority of the Negro structure, both in the conformation and relative dimensions of the brain; and he ascribes the erroneous notions which have been hitherto entertained on these subjects chiefly to prejudice created by the circumstance that the facial angle

in the negro is smaller than in the European, and consequently makes, in this respect, an approach to that of the ape, in which it is still farther diminished. The author denies that there is any innate difference in the intellectual faculties of these two varieties of the human race; and maintains that the apparent inferiority of the Negro is altogether the result of the demoralizing influence of slavery, and of the long-continued oppression and cruelty which have been exercised towards this unhappy portion of mankind by their more early civilized, and consequently more successful competitors for the dominion of the world.

June 16.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

Moses Montefiore, Esq., was elected a Fellow of the Society.

The following papers were read, viz.

1. "Researches on the Tides; Sixth Series. On the Results of an extensive system of Tide Observations, made on the Coasts of Europe and America, in June 1835." By the Rev. William Whewell, F.R.S., Fellow of Trinity College, Cambridge.

The author having, in several previous communications to the Royal Society, urged the importance of simultaneous tide observations made at distant places, here gives an account of the steps taken to carry this plan into effect, in consequence of his representations, both by the Government in England, and by the other maritime powers of Europe. He explains, in the present paper, the general character of the observations thus obtained, the mode employed in reducing them, and enters at considerable length into a discussion of the immense mass of information which they supply with respect to the phenomena of the tides. One of his principal objects was to fix with precision the form of the *Cotidal lines* by which the motion of the tide wave is exhibited. He devotes one section of the paper to an investigation of the general form of these lines; and another to a nearer approximation to an accurate map of these lines, more especially as they exist in the German Ocean. The 4th section treats of the height of the tide in its total range from high to low water; the 5th relates to the diurnal inequality; the 6th to the semimenstrual inequality; and the 7th and last comprises general remarks on the tables which accompany the paper.

2. "On the Tides at the Port of London." By J. W. Lubbock, Esq., F.R.S.

The discussions of tide observations which the author has hitherto at various times laid before the Society, were instituted with reference to the transit of the Moon immediately preceding the time of high-water; from which the laws of the variation in the interval between the moon's transit and the time of high-water have been deduced. But the discussion of nineteen years' observations of the tides at the London Docks, which is given in the present paper, has been made with reference to the moon's transit two days previously, and proves very satisfactorily that the laws to which the phenomena are subject

accord generally with the views propounded long since by Bernoulli. The relations which the author points out between the height of high-water and the atmospheric pressure as indicated by the barometer are particularly interesting and important. The influence of the wind is also considered; and such corrections indicated as are requisite in consequence of the employment by several observers of solar instead of mean time.

3. "Discussion of the Magnetical Observations made by Captain Back, R.N., during his late Arctic Expedition." By Samuel Hunter Christie, Esq., M.A., F.R.S. Part II.

The author proceeds, in this paper, which is a sequel to his former communication, to discuss the observations made by Captain Back relating to the magnetic intensity, and which were of two kinds; the first, obtained by noting the times of vibration of a needle in the plane of the magnetic meridian; the second, by noting the times of vibration of three needles suspended horizontally according to the method of Hansteen. The results are given in the form of tables.

Before deducing results from these observations, the author describes a series of experiments instituted with each needle, for the purpose of determining the corrections necessary to be applied in order to reduce the intensities, which would result from observations made at different temperatures, to intensities at a standard temperature; and he gives formulæ for these corrections. He then determines the relative terrestrial magnetic intensities, at the several stations where observations were made, from the times of vibration of the dipping needle in the plane of the meridian, applying the corrections which he had obtained for difference of temperature; and gives the results in tables. A comparison is instituted between these results and a formula derived from the hypothesis of two magnetic poles not far removed from the centre of the earth. The author considers that this comparison is quite conclusive against the correctness of the formulæ, and consequently of the hypothesis itself, if applied to the results deduced from the observations in London, in conjunction with those in America; but that, in the tract of country comprised by Capt. Back's observations from New York to the Arctic Sea, the phenomena of terrestrial magnetic intensity are very correctly represented by the formula in question.

The author then proceeds to determine the intensity from the observations with horizontal needles, applying here, likewise, to the results, corrections for the difference in the temperatures at which the observations were made. In these results there are great discrepancies, which the author attributes to the inapplicability of Hansteen's method of determining the intensity by the times of vibration of horizontal needles to cases where the dip of the needle is very great, rather than to errors in the observations themselves, or to a variation in the magnetism of the needles employed. He concludes by a just tribute to the zeal which Captain Back has manifested in the cause of science, by availing himself of every opportunity of making these tedious observations, during an unknown and perilous navigation.

4. "On the Powers on which the Functions of Life depend in the more perfect Animals, and on the Manner in which these Powers are associated in their more complicated results." By A. P. W. Philip, M.D., F.R.S.

This paper is divisible into three portions. In the first, the author considers the functions and seat of each of the powers of the living animal ; in the second, the nature of each power ; and in the third, the manner in which they are associated in the more complicated results which constitute life.

Of these powers the simplest is the muscular, which consists merely in a contractile power residing in the muscular fibre itself : and various experiments are referred to in proof that it depends exclusively on the state of this fibre, and in no degree on that of the nervous system, which some physiologists have regarded as the real seat of this power : for, instead of being recruited, it is exhausted by the action of the nervous system upon it, as it is by other stimulants.

The next power considered is that of the nervous system, properly so called, in contradistinction to the sensorial system. The result of an extensive series of experiments made with a view to establish the exact line of distinction between these two systems, is that the functions of the nervous power are as remarkable for their complexity as that of the muscular power is for its simplicity. With regard to the nervous power it is shown that its functions (all of which are capable of existing after the sensorial power is withdrawn, and all of which fail when the nervous power is withdrawn,) are the following : 1. The excitement of the muscles of voluntary motion in all their actions ; 2. The occasional excitement of the muscles of involuntary motion ; 3. The maintenance of the process by which animal temperature is maintained ; 4. The maintenance of the various processes of secretion ; 5. The maintenance of the processes of assimilation. It farther appears, from several experiments, that the seat of the nervous power is exclusively in the brain and spinal cord ; not, however, in any particular part, but in the whole extent of these organs, from the uppermost surface of the former to the lowest portion of the latter ; with the exception only that the lower portions of the spinal cord partake less of this power than the rest. It appears also that the nerves are only the medium of conveying the influence of the above-mentioned organs ; and their ganglions and plexuses are only the means of combining the power of all the parts of these organs ; such combination being shown to be necessary to the due excitement of the muscles of involuntary motion, and for the maintenance of the functions of secretion and assimilation.

The remaining powers of the living animal are the sensorial powers, and the powers of the living blood. The first of these classes of powers has its seat, not in the whole brain and spinal cord, as is the case with the nervous power, properly so called, but in certain parts of them ; these parts being, in man, almost wholly confined to the brain ; while in some animals they extend also to a considerable portion of the spinal cord. The functions of the sensorial powers are those strictly termed mental, of which sensation and volition are the simplest, and

the only powers of this class which are concerned in the maintenance of life.

The functions of the living blood are evidently those of supplying the proper materials, in their requisite condition, (to the preservation of which the vital powers are essential,) for the action of the nervous power, properly so called, in the processes of secretion and assimilation. The seat of the powers of the blood is in itself; as appears from its retaining them for a short time after it is separated from the body.

These four vital powers, viz. the muscular, the nervous, the sensorial, and that of living blood, have no direct dependence on one another; for each can, for however short a time, exist independently of the others: but each has an indirect dependence, more or less remote, on all the other three for the maintenance of their organs.

The author then proceeds to inquire into the nature of these several powers. The sensorial and muscular powers, and the powers of the living blood, are manifestly peculiar to the living animal, no analogous powers being perceptible in inanimate nature. But this exclusiveness does not belong to the nervous power, for experiment shows us that when the oxygen and carbon of the blood are combined by its influence, a substance results which is identical with that produced in the laboratory of the chemist. An analogy, too strong to be wholly disregarded, exists therefore between its effects and those of the powers which operate in inorganic nature. This consideration, as well as others stated by the author, induced him to make many experiments to determine how far the other functions of the nervous influence bear a similar analogy to the operations of inanimate nature; and, in particular, to inquire whether voltaic electricity, applied under the same circumstances as those under which the nervous influence operates, and applied after the removal of that influence, and the consequent cessation of its functions, would produce the same effects. His endeavours were crowned with complete success; all the functions of the nervous power being capable, as far as he and others could judge, of being perfectly performed by voltaic electricity. He states that the results of his experiments on this subject were confirmed by a public repetition of them both in London and in Paris; as were likewise those of another set of experiments suggested by the following reasoning. If the nervous influence could be made to pass through any other conductor than the nervous textures to which it belongs in the living animal, we should have a proof, independent of all other evidence, that this influence is not a vital power, properly so called; because it must be universally admitted that such a power can exist only in the texture to which it belongs. In this attempt he was for some time baffled; but at length, overcoming the obstacles which had impeded his efforts, he succeeded: and, having undergone the same public ordeal as the former, the results are no longer questioned. From the whole of these experiments the author thinks himself warranted in concluding that the nervous influence is not a vital power, properly so called; and that when it is admitted that voltaic electricity is capable of performing all its functions, the proposition that they

are powers of a different nature would be a contradiction in terms, for it is only by its properties that any principle of action can be distinguished.

He refers, in confirmation of these inferences, to the recent investigations of Mr. Faraday, from which it appears that electricity is the agent in all chemical processes; to the facts which prove that all the functions of the nervous influence, properly so called, are of a chemical nature; and also to the late experiments of Dr. Davy on the Torpedo, tending to show that the electric power, peculiar to electric animals, is a function of the brain, and thus affording direct proof that the brain has the power of collecting and applying, even according to the dictates of the will, the electric power.

It farther appears, from the facts referred to in this paper, that, whenever we can trace any analogy between the functions of the living animal and the operations of inanimate nature, an agent belonging to the external world is employed; that these functions are the results either of such agents acting on vital parts, or of vital parts acting on them; and that the sensorial functions, on the other hand, in which no such analogy can be traced, are the effects of vital parts acting on each other, and influencing each other by their vital properties alone.

In the concluding part of the paper the author considers the various functions of the living animal as forming two systems, in a great measure distinct from one another, in each of which all its powers are employed, but in very different ways: the object of the one of these systems being the maintenance of the body itself; of the other, the maintenance of its intercourse with the external world. The manner in which the different powers of the living animal are employed in the construction of each of these systems is pointed out; and the bonds of union which exist between them, and thus form the living body into a whole, no part of which can be affected without tending more or less to affect every other, are considered. These bonds of union consist chiefly in the employment of the same powers in the construction of both systems, and in the function of respiration, which so extensively influences all other functions both in health and disease, as pointed out by the author in his papers on the nature of sleep and death, and which differs from all the other vital functions in partaking of the sensorial as well as of all the other powers of the living animal.

5. "On the Respiration of Insects." By George Newport, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

Although a multitude of facts has been collected relating to the physiology of respiration in insects, attention has seldom been directed to the variations exhibited in this function in the different periods of their existence. The author gives an account, in this paper, of the anatomical and physiological peculiarities which he has noticed in various insects, in their three states of larva, pupa, and imago. He traces all the several changes which the tracheæ and spiracles undergo during their transformations; describing particularly the successive development of the air vesicles in connexion with the power of flight.

The system of muscles, both of inspiration and of expiration, is minutely detailed, and their various modes of action examined. He next investigates the series of nerves appropriated to the exercise of the respiratory function, and establishes a distinction in the offices of these nerves, corresponding to the sources from which they derive their origin, and presenting remarkable analogies with similar distinctions in the nerves of vertebrate animals. The manner in which respiration is performed, and the phenomena presented with regard to this function under various circumstances, such as submersion, and confinement in unrespirable or deleterious gases, are next considered. An account is then given of a series of experiments made with a view to determine the quantity of oxygen consumed, and of carbonic acid produced, by the respiration of various kinds of insects in different states, from which the conclusion is drawn that the quantity of air deteriorated is governed by several circumstances not necessarily connected with the natural habits of the species. When the insect is in its pupa state, and in complete hybernation, its respiration is at its minimum of energy: and, on the contrary, it is at its maximum when the insect is in the imago state, and in the condition of greatest activity.

In the concluding section of the paper the author institutes an inquiry into the capabilities which insects possess of supporting life, during longer or shorter periods, when immersed in different media: and gives a tabular view of the results of numerous experiments which he made on this subject. It appears from these observations that the order in which these media possess the power of extinguishing vitality is the following: viz. hydrogen, water, carbonic acid, nitrous acid gas, chlorine, and cyanogen. Some of these agents, however, affect respiration much more rapidly than others, which, though their action is slower, are eventually more fatal to the insect.

6. "Démonstration de l'égalité à deux droits de la somme des angles d'un triangle quelconque, indépendamment de la théorie des parallèles, et de la considération de l'infini." Par M. Paulet, de Genève. Communicated by P. M. Roget, M.D., Sec. R.S.

The author demonstrates the equality of the sum of the angles of a triangle to two right angles, by the aid of a preliminary theorem, of which the following is the enunciation. A straight line forming an acute angle with another straight line, will, when sufficiently produced, meet any line, perpendicular to the latter, and situated on the side of the acute angle.

7. "Experimental Researches into the Physiology of the Human Voice." By John Bishop, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The following are the conclusions deduced by the author from the inquiries which form the subject of the present paper.

1. The vibrations of the glottis are the fundamental cause of all the tones of the human voice.

2. The vibrating length of the glottis depends conjointly on the

tension and resistance of the vocal ligaments, and on the pressure of the column of air in the trachea.

3. The grave tones vary directly, and the acute tones inversely, as the vibrating length and tension of the vocal ligaments.

4. The vocal tube is adjusted to vibrate with the glottis by the combined influence of its variations of length and of tension.

5. The elevation of the larynx shortens the vocal tube; and its depression produces the contrary effect. The diameter and extension of the tube vary reciprocally with the length.

6. The falsetto tones are produced by a nodal division of the column of air, together with the vocal tube, into vibrating lengths.

7. The pitch of the vocal organs, when in a state of rest, is, in general, the octave of their fundamental note.

The paper is illustrated by several drawings.

8. "Du Son et de l'Electricité." Anonymous, with the signature of *Hermes*. Being a Prize Essay for the Royal Medal.

This paper contains the account of a great number of facts and observations, collected from various sources, on the subject of the relations subsisting between electricity, the production of sound, the crystallization of bodies, the transmission of heat, the emission of light, and various atmospheric changes; from the consideration of which the general conclusion is drawn that all these phenomena are perhaps the results of the undulations of some ponderable material.

9. "Physiological Remarks on several Muscles of the Upper Extremity." By F. O. Ward, Esq., Medical Student at King's College, London. Communicated by P. M. Roget, M.D., Sec. R.S.

There is a remarkable fold in the tendon of the pectoralis major muscle, described by all anatomists, but the purpose of which has never yet, as the author believes, been explained. The muscle itself consists of two portions, one smaller and upper, arising from the clavicle, and passing downwards and outwards to an insertion in the humerus at a greater distance from the shoulder-joint than the place where the tendon of the larger and lower portion of the muscle, which arises from the sternum and ribs, and has a general direction upwards and outwards, terminates. Thus the respective portions of tendon belonging to the two divisions of the muscle are found to cross each other; the margin of that proceeding from the lower division passing behind, and appearing above that which proceeds from the upper fibres of the muscle. The forces exerted by each portion of the muscle being thus applied to parts of the bone at different distances from the fulcrum, act with different mechanical powers; which the author finds in every case to correspond exactly with the variations in the effects required to be produced, under different circumstances, by these muscular actions. Those muscular fibres, the tendon of which is inserted nearest to the centre of motion, and which consequently act by a shorter lever, are adapted to motions requiring a less force, but a greater velocity: and such is precisely the mechanical condition of the lower portion of the pectoralis major, which is employed more

especially in bringing down the arm, when previously raised, as in striking with the hammer, pickaxe, &c., where velocity is chiefly required, the weight of the instrument held in the hand sufficiently supplying the diminution of force. On the contrary, the lever by which the upper portion of the same muscle is enabled to act being, from the more distant insertion of its tendon, of greater length, is calculated to procure force at the expense of velocity, and is therefore peculiarly fitted for the performance of those actions by which the arm is elevated and weights raised; these being precisely the actions in which such muscles are employed. Adverting, also, to the respective obliquities in the direction of their action, the author traces the same express correspondence between the mechanism employed and the purpose contemplated. He pursues the same line of argument and obtains the same results in extending the inquiry to the structure and uses of those muscles, such as the coraco-brachialis, and the anterior fibres of the deltoid, which cooperate with the upper division of the pectoralis major; and the teres major and latissimus dorsi, which combine their actions with that of the lower division of the pectoral muscle.

This diversified adaptation of parts, he observes, forms the chief characteristic of the mechanism of Nature. Operating with unlimited means, she yet works with scrupulous economy; in all her structures no power is redundant, nor a single advantage lost: so that, however completely an arrangement may be subservient to one primary purpose, we find, on renewed examination, an equally accurate adjustment to various secondary and no less important ends.

The author then proceeds to inquire into the methods employed for determining the absolute and relative strength of muscles; and proposes, for that purpose, the application of the constant and equable stream of galvanism afforded by the new battery invented by Mr. Daniell.

10. "An Experimental Inquiry into what takes place during the Vinous, the Acetous, and different Putrefactive Fermentations of dissolved Vegetable Matter; and an Examination of some of the Products." By Robert Rigg, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

The author describes with great minuteness a long train of experiments on the subjects announced in the title of the paper. His first object of inquiry is into the nature of the changes which take place during the vinous fermentation; and the conclusion to which he arrives is, that in the formation of the products resulting from this process sugar is not the only vegetable principle which is decomposed, but that the changes consist in the combination of two equivalents of carbon, derived from the sugar of the malt, or other vegetable matter, ($= 12.24$) with two equivalents of hydrogen from water ($= 2$) forming 14.24 parts of olefiant gas: and in the combination of one equivalent of the carbon from the sugar, &c. ($= 6.12$) with two equivalents of oxygen from water, ($= 16$) forming 22.12 parts of carbonic acid. He thinks that, on this change taking place, the olefiant

gas is held in solution by the water by an affinity which can be overcome, and that the foreign matter which, with the carbon, formed the sugar, or other vegetable substance, is then at liberty to form new combinations. He finds that the products resulting from the decomposition exceed the weight of the sugar, or other vegetable matter, by about 10 per cent. of the former, and from 11 to 12 per cent. of the latter, as calculated according to the prevailing theory that sugar, or vegetable matter, is the only substance decomposed during the process of vinous fermentation.

From his analysis of sugar he obtains certain proportions of water and of carbonic acid which are different from those given by preceding chemists, the carbonic acid being 45 to 45.5 per cent. His analysis of alcohol gives him 59.7 to 60 per cent. of olefiant gas, the remainder being water.

His experiments on the acetous and putrefactive fermentations are numerous and elaborate, and the results, which are nearly the same as those of former analyses, are given in a tabular form. He finds that in the acetous fermentation 57 parts by weight of olefiant gas, 5 of sugar, or other vegetable matter, and 64 of oxygen from the atmosphere, combine to form 100 parts of acetic acid, and about 24 of water; leaving an insoluble substance at liberty to form other combinations: and thus includes in his account of this process the decomposition of vegetable matter, which is overlooked in the generally received theory.

During the putrefactive fermentation of vinous fermented liquors, when exposed to the atmosphere, the author considers that one equivalent of carbon from the olefiant gas ($= 6.12$) unites with two of oxygen from the atmosphere ($= 16$) to form 22.12 parts of carbonic acid: while one equivalent of hydrogen from the olefiant gas ($= 1$) combines with one of atmospheric oxygen ($= 8$) to form 9 parts of water; a portion of sugar, or other vegetable matter, being also decomposed; and an insoluble substance remaining, which, on exposure to the air, undergoes further decomposition, and forms products highly deleterious. The author is not aware that this latter decomposition has been hitherto noticed.

During the putrefactive fermentation of acetic acid exposed to the atmosphere, he regards one equivalent of carbon from acetic acid ($= 6.12$) as combining with two of atmospheric oxygen ($= 16$) to form 22.12 parts of carbonic acid: the oxygen and hydrogen, with which the carbon had formed the acetic acid, remain in the state of water, as they are found by analysis in this substance: a portion of vegetable matter is also decomposed; and an insoluble substance left behind. Other substances are also formed during some of the changes resulting from exposure to the air.

During the direct putrefactive fermentation of solutions of sugar, or other vegetable matters, he finds, that one equivalent of its carbon ($= 6.12$) unites with two of atmospheric oxygen ($= 16$) to form 22.12 parts of carbonic acid; leaving the water and an insoluble substance to undergo changes as before mentioned. The olefiant gas, formed during the vinous fermentation, whether the liquor be in the

state of vinous fluid, weak spirit, strong spirit, or even of alcohol, or ether, is subject to precisely the same decomposition, under favourable circumstances for such changes, without any action upon, or relation to the water which may happen to be combined with it in each kind of liquor. This olefiant gas cannot, either by distillation or other means, be separated along with any of the water with which it is at first combined, and again united with the same materials, without forming a compound different from the original one: and in proportion as water is, by any means, removed, we obtain it in a somewhat different state; and this happens without reference to a separate and distinct substance which we may call alcohol, or ether. Thus neither of these two ill-defined substances ought to be regarded as a separate and distinct principle; but the whole series of bodies, from the weakest fermented liquor, separated from its vegetable matter, to the most highly rectified ether, consist only of different combinations of olefiant gas, the first product of vinous fermentation, and water.

11. "On the Chemical Changes occurring in Seeds during Germination." By the same.

The author infers, from his researches on the subject of his second paper, that during the process of germination there is a production of alcohol, and that oxygen unites with olefiant gas, under the influence of the radicle and plumula. He accounts for the increase of temperature during germination by an alleged difference in the specific heats of the principles before and after that process has commenced; but the methods he employed for establishing the reality of this difference are not detailed.

The following are the principal conclusions to which the author arrives:

1. Seeds may, by careful desiccation, be deprived of much water without injuring their vegetating organs.

2. Their capacity for absorbing water varies with the temperature at which they are kept.

3. The increase taking place in their volume by the absorption of water is influenced by temperature.

4. On steeping seeds in water at one temperature the vinous fermentation takes place, but at another this process does not occur.

5. A decomposition takes place in seeds previously to their germination, and the products are carbonic acid and olefiant gas.

6. The abstraction of carbon from seeds by the oxygen of the atmosphere is not, as is generally supposed, the specific action which gives rise to germination; but it rather conduces to putrefaction.

7. The germination of seeds appears to be an action taking place between the olefiant gas, which has been previously formed by a vinous fermentation, and the oxygen of the atmosphere; and is effected by the peculiar operation of the plumula and the rootlets.

8. This decomposition and combination of the different elements go on, in well-regulated processes, as long as there is any farinaceous matter to be decomposed: the food of the plant being at this time always the oxygen of the atmosphere, and the newly-formed olefiant

gas, differing in equivalent combinations, according to the peculiar constitution of the plant; and thus the foundation is laid for all that prodigious diversity which characterizes the numberless species of the vegetable creation.

12. "A Comparison of the late Imperial Standard Troy Pound Weight with a Platina copy of the same, and with other Standards of authority." Communicated by Professor Schumacher, in a Letter to Francis Baily, Esq., V.P. and Treas. of the Society.

Professor Schumacher being desirous of procuring an accurate copy of the English Imperial Standard Troy pound weight, for the purpose of comparison with the Danish weights, applied to Capt. Kater, requesting him to cause such copy to be made; which was accordingly done. It was made of brass by Bate; but the result of the weighings not being satisfactory to Professor Schumacher, he desired to have a second copy forwarded to him. As these two copies did not agree in their results, the first was returned to Capt. Kater with a request that he would repeat the weighings. The result confirmed Professor Schumacher's suspicions: and as it was not thought proper that, in an affair of so much importance as the comparison of the standard weights of two nations, any source of discordance should exist, or even be suspected, (the preceding experiments having been made with a *copy* of the Imperial standard weight) the Danish Government sent over Capt. Nehus (of the Royal Danish Engineers) to this country for the express purpose of making comparisons with the *original* standard, in the possession of the Clerk of the House of Commons.

The weighings took place in the Apartments of this Society, and were partly made with Ramsden's balance, belonging to the Society. Besides the first brass weight above mentioned, there was another brass weight made by Robinson, a platina weight made by Cary, the brass pound weight belonging to the Royal Mint, and the platina pound weight belonging to this Society. These were all subjected to a most rigid and accurate series of weighings by Capt. Nehus, in which every precaution was taken to insure the most correct results. It would be impossible here to follow Capt. Nehus through all his details: but it may be sufficient now to state that upwards of 600 comparisons were made with the English Imperial standard, all of which are apparently very accordant; but, on account of a singular circumstance connected with the *original* standard, do not possess that degree of precision, nor afford that satisfaction which ought to attach to an affair of so much importance. For, it appears that not only the specific gravity of the original standard had never been ascertained, but that we are even ignorant of the kind of metal of which it was composed: some persons maintaining that it was of brass, others of copper, and others of bell-metal. And, as the original was totally destroyed in the late fire which consumed the two Houses of Parliament, we cannot now supply this omission. It is well known that the specific gravity of brass may vary from 7.5 to 8.5; so that a difference of at least $\frac{1}{4}$ of

a grain might arise from this circumstance alone; setting aside a number of other particulars that require minute attention, and which do not seem to have been attended to in former experiments of this kind. In fact, as Professor Schumacher remarks, though we have thus five different pounds in excellent preservation, and compared with the lost standard, with the greatest care and the best instruments, though the number of these comparisons exceeds 600, yet there still remains an uncertainty as to its real weight; and this solely on account of its specific gravity and expansion not being known. And, he adds, that it is to be hoped that no pound will in future be declared a legal standard unless these elements (the knowledge of which is indispensable even for a single comparison with a good balance) are previously determined with the greatest possible precision.

Besides the account of these numerous weighings, which are stated in detail, Professor Schumacher has given various formulæ and tables which will be found of great use and application in any future experiments of a like kind that may be undertaken.

13. "On the Application of a New Principle in the Construction of Voltaic Batteries, by means of which an equally powerful current may be sustained for any period required; with a description of a sustaining battery recently exhibited at the Royal Institution." By Frederick W. Mullins, Esq., M.P., F.S.S. Communicated by N. A. Vigers, Esq., F.R.S.

The method resorted to by the Author for obtaining a continuous voltaic current of equal intensity, is the same in principle as the one employed by Professor Daniell, and described by him in his paper recently presented to the Royal Society, and published in the Philosophical Transactions; namely, the interposition of a thin membrane between the two metals in the voltaic circuit, so as to allow of the separation of the different fluids applied respectively to each metal: the fluid in contact with the zinc being a mixture of diluted sulphuric and nitric acids; and that in contact with the copper being a solution of sulphate of copper. The author reserves for a future paper the details of the results he has obtained, with regard to the relations between the intensity of effect, and the extent and disposition of the metallic surfaces: but states that he has obtained powerful electric action by bringing the membrane into contact with the zinc; the latter having no acid applied to it, and the only fluid employed being the solution of sulphate of copper.

14. Anonymous Essay, entitled "*Scoperta della Causa Fisica del Moto.*" Presented to the Royal Society, with a view to obtaining one of the Royal Medals for 1836.

The Author commences by an historical review of the opinions of almost every philosopher, both ancient and modern, who has treated of the subject of motion, from Pythagoras to Le Sage: and proceeds to state his own ideas relating to the cause of motion,

founded on the hypothesis that the ultimate atoms of all matter have a pyramidal figure.

15. "An Experimental Inquiry into the Modes of Warming and Ventilating Apartments." By Andrew Ure, M.D., F.R.S.

The Author, having been consulted by the Directors of the Customs Fund of Life Assurance, on the mode of ventilating the Long Room in the Custom House, and deeming the subject one of great public interest, was induced to lay the result of his observations and experimental inquiries before the Royal Society. In this room, about two hundred persons are busily engaged in transacting the business of the Institution. All these persons are found to suffer more or less from ailments of the same general character, the leading symptoms of which are a sense of fulness and tension in the head, flushing of the face, throbbing of the temples, giddiness, and occasional confusion of ideas, depriving them of the power of discharging their duties, in which important and frequently intricate calculations are required to be gone through. These symptoms of determination of blood to the head are generally accompanied by coldness and languid circulation in the feet and legs, and by a feeble, and frequent, as well as quick and irritable pulse. On examining the air of the room by appropriate instruments, the author notices more especially three circumstances in which it differs from the external air: first, its temperature, which is maintained with great uniformity within a range of 62° to 64° ; secondly, its extreme dryness, which, on one occasion, measured by Daniell's hygrometer, was 70 per cent.: and thirdly, its negatively electrical state, as indicated by the condensing gold-leaf electrometer. In all these qualities the air respired by the inmates of the room bears a close resemblance to the pestilential blasts of wind which, having passed rapidly over the scorching deserts of Arabia and Africa, constitutes the *Simoom* of those regions, and is well known by its injurious effects on animal and vegetable life. To these noxious qualities is superadded, as in the air of all rooms heated through the medium of cast-iron pipes or stoves, an offensive smell, arising partly from the partial combustion of animal and vegetable matters always floating in the atmosphere of a town, and perhaps also from minute impregnations of carbon, sulphur, phosphorus, or even arsenic, derived from the metal itself. The Author expresses his surprise that in the recent report of the Parliamentary Committee on the subject of ventilation, no reference is made to the methods employed for that object in factories, although they afford the best models for imitation, being the results of innumerable experiments made on a magnificent scale, with all the lights of science, and all the resources of the ablest engineers. He proceeds to describe these methods; and is then led to investigate the comparative efficiency, with a view to ventilation, of a draught of air resulting from a fire and chimney, and that produced by the rotation of a fan-ventilator. He shows that a given quantity of coal employed to impart motion to the latter, by means of a steam-engine, produces a ventilating

effect 38 times greater than can be obtained by the consumption of the same fuel in the ordinary mode of chimney ventilation. Accordingly, he strongly advises the adoption of the former in preference to the latter: and inveighs against the stove-doctors of the present day, who, on pretence of economy and convenience, recommend the slow combustion of a large body of coke, by means of a slow circulation of air; under which circumstances, it is well known to chemists that much carbonic oxide, a gas highly pernicious to all who respire it, is generated; accompanied, at the same time, by a comparatively small evolution of heat. In order to obtain the maximum quantity of heat from a given mass of fuel, its combustion, he observes, should be very vivid, and the evolved caloric should be diffused over the largest possible surface of conducting materials; a principle which has been judiciously applied in several French factories. It has been proved that work-people employed in calico-drying rooms, heated according to the plan here reprobated, become wan, emaciated, and diseased; while in rooms in which the air is more highly heated by means of steam-pipes, they preserve their health and florid complexion.

16. "An Experimental Inquiry into the Relative Merits of Magnetic Electrical Machines and Voltaic Batteries, as Implements of Philosophical Research." By William Sturgeon, Esq., Lecturer on Natural and Experimental Philosophy at the Honourable East India Company's Military Academy at Addiscombe. Communicated by P. M. Roget, M.D., Sec. R.S.

The first part of this paper is occupied by a description of two forms of constructing the magnetic electrical machine, which the author has adopted; and the second, with the particulars of some experiments made with a view to determine the respective powers of these machines as compared with the common voltaic battery. In the first form of the instrument, a reel, round the periphery of which 200 feet of copper wire, one 20th of an inch in diameter and covered with stout sewing-silk, are coiled, is made to revolve on a spindle, placed in the axis of a system of horse-shoe magnets, so as to remain within the branches of the latter during its whole revolution. The electric currents produced in the copper wire by magnetic induction, while the coil is moved at right angles to the plane of the magnets, are conducted by means of four semicircular metallic flanges attached to the spindle, into cisterns of mercury, the one being positive, and the other negative; and which consequently act as the two poles of the battery. In the second form of the apparatus, a piece of soft iron, of which the ends are bent into the shape of two arms, and which is surrounded with a coil of 300 feet of copper wire, is made to revolve in front of the poles of a horse-shoe magnet; its axis of motion coinciding with that of the magnet; and the electrical currents determined in the wire by this rotation, being collected in the same manner as in the former instrument.

The author next details several series of experiments which he made for the purpose of ascertaining the relation observable be-

tween different velocities of rotation in these instruments and the corresponding effects : first, with regard to the deflection of a magnetic galvanometer ; secondly, with regard to chemical decompositions ; thirdly, with regard to the production of sparks ; and lastly, with regard to the intensity of the shock communicated to the human body. He compares the effects produced by the magnetic electrical battery, first, when the coil consisted of one continuous length of wire ; secondly, when the coil was doubled upon itself so as to constitute two sets of conductors of half the length of the former ; thirdly, when, upon being again doubled, it composed four conductors of one quarter of the length of the first ; and lastly, when, on being doubled a third time, the electric current was made to pass through eight wires, each one eighth of the original length of the single wire. It was found that by thus multiplying the channels of conduction, although both the magnetic and the luminous effects continue to be produced with scarcely any sensible difference of intensity, the power of effecting chemical decompositions becomes more and more impaired, and the physiological influence is weakened in a still more remarkable degree. In the four-stranded coil, indeed, no shock whatever could be produced, however rapidly the instrument was made to revolve. The author endeavours to account for these variations of effect by the diminution of velocity in the electric current, its quantity remaining unaltered, consequent on its division into several streams by the multiplied channels offered to its progress. He also tried the effects of conjoining the magnetic electrical machine with ordinary voltaic combinations ; sometimes acting in cooperation, and at other times in opposition to one another ; and notices the corresponding results, which were sufficiently accordant with theory.

17. "Welt Mechanik." By M. Kropalschek.

The object which the author has in view, in this paper, is to overturn the theory of universal gravitation, as regulating the planetary motions. The memoir is divided into two parts ; in the first, he disputes the accuracy of Kepler's law respecting the description of equal areas in equal times, and endeavours to confute the fundamental doctrines of astronomy relating to the elliptical orbit of the earth, the difference between solar and mean time, and the whole theory of the motions of the moon and the planets. In the second part, the author enters into a detailed exposition of his own views of the mechanism of the heavens ; and devotes 215 closely written pages to the development of a perfectly new hypothesis, which he advances, founded on a supposed variation of the progressive motion of the planets, in an orbit perfectly circular, and by which he thinks he can explain all the phenomena they present to observation.

18. "Plan et Esai d'un nouveau Catalogue Sidéral, avec une représentation graphique, et une loi de simple et régulière distribution des étoiles autour du Pole, qui pourra fournir plusieurs avantages à

l'Astronomie pratique." By Professor Joseph Bianchi, Superintendent of the Observatory at Modena.

The Author proposes the construction of a new sidereal catalogue, accompanied with a graphic representation of all the stars visible within the field of view at each observation, by means of the meridian transit of the most conspicuous stars across the field of a telescope of four inches aperture, attached to a three-feet circle. He directs this telescope to any elevation of the heavens that happens to be clear; and bringing any conspicuous star to the horizontal wire, he watches its transit over the two first vertical threads; then, suddenly intercepting the light, makes a diagram of all the stars in the field down to the 12th magnitude; and this he performs with sufficient expedition to enable him, on restoring the light, to observe the transit of his principal star over the fourth and fifth threads. The author has appended to the description of his method explanatory drawings, displaying 600 fields, of which the principal star in each, has its right ascension and declination determined. He subjoins some remarks on the rate of clocks, as influencing the observations on the upper, lower, and opposite passages; and proposes a plan for a system of symbols expressive of the relative magnitude of the stars recorded in his catalogue.

The author farther states as one of the most important results of his researches the probable existence of a general and curious law of position in the stars, namely, that they are distributed in pairs; each star having a corresponding one in the opposite meridian, very nearly of the same declination and magnitude; a coincidence which he considers as extremely favourable to the execution of his project for the accurate determination of the position in the heavens of every star.

19. "On the Composition and Decomposition of Mineral Waters." By the Rev. George Cooke, LL.B. Communicated by J. G. Children, Esq., Sec. R.S.

20. "Inquiries concerning the Elementary Laws of Electricity," Part II. By William Snow Harris, Esq., F.R.S.

21. "A New Theory of the Constitution and Mode of Propagation of Waves on the Surface of Fluids." By H. J. Dyar, Esq. Communicated by Edward Turner, M.D., F.R.S.

The Society adjourned over the long vacation, to meet again on the 17th November next.

June 23, 1836.

At a Special General Meeting of the Royal Society, convened by order of H. R. Highness the President and Council, to take into consideration the principle of the Resolution passed on the 5th of May, which goes to withhold the thanks of the Society from the author of a work presented by him to the Society ;

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair ;

The Secretary, by direction of the Chairman, read a requisition, signed by Dr. Granville and five other Fellows, to convene a Special General Meeting of the Royal Society for the purpose of considering and determining the necessity of expunging from the Journal-Book of the Society the minutes of certain Resolutions passed at three several ordinary meetings on account of an alleged informality, and also the principle of the Resolution of the 5th of May, which goes to withhold the thanks of the Society to the author of a work presented by him to the Society, which requisition was delivered to the Secretary at the ordinary meeting on the 2nd instant.

The Chairman then informed the Society, that, upon the above requisition being laid before the Council, they passed the following resolutions, viz.

“ That it is the unanimous opinion of His Royal Highness the President, and the Council, that no Special Meeting has the power of expunging minutes of past proceedings of the Society.”

“ That a General Special Meeting of the Society be called on the 23rd instant, at two o'clock, for the purpose of taking into consideration that part of the above requisition which proposes to afford to the Society an opportunity of taking into consideration the principle of the Resolution passed on the 5th ult., which goes to withhold the thanks of the Society from the author of a work presented by him to the Society.”

The Chairman then made a statement of what had taken place at the meetings of the Society with regard to the Resolutions referred to in the above requisition.

On being asked by a Fellow present, by what authority the present meeting had been convened, he referred him to Statute I. Chap. XII. of the Statutes, which is as follows :

“ The President or Council may at any time call a Special General Meeting of the Society when it may appear to them to be necessary.”

It was then moved and seconded, That, in the opinion of this meeting, the meeting of May the 5th exercised a sound discretion in refusing thanks to Dr. Granville for his publication entitled “The Royal Society in the XIXth Century”; which motion, being put, was carried in the affirmative.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1836.

No. 27.

November 17, 1836.

FRANCIS BAILY, Esq., V. P. and Treasurer, in the Chair.

The following Gentlemen were, by ballot, elected Auditors of the Treasurer's Accounts on the part of the Society, viz.: George Biddell Airy, Esq., A.R.; John Bostock, M.D.; the Rev. George Peacock, M.A.; William H. Pepys, Esq.; and the Rev. Adam Sedgwick, M.A.

"Researches in the Integral Calculus." Part II. By Henry Fox Talbot, Esq., F.R.S.

Having explained, in the first part of his paper, a general method of finding the sums of integrals, the author proposes, in the second place, to apply this method to discover the properties of different transcendents, beginning with those of the simplest nature. With this view, he first shows its application to the arcs of the circle and the conic sections; and demonstrates the possibility of finding three arcs, such that, neglecting their signs, the sum of two of them shall be equal to the third, though not superposable in any part: an equality which has been hitherto deemed impossible in the ellipse and hyperbola, without the addition of some algebraic quantity.

At a Special General Meeting of this Society, held after the ordinary Meeting of the 17th of November, to consider of an Address to H.R.H. the President, on the happy recovery of his sight, It was Resolved unanimously, That this meeting feels great pleasure in congratulating H.R.H. the President of this Society, on the happy restoration of his sight, a blessing which they sincerely hope he may long enjoy for his own happiness and for the benefit of science.

November 24, 1836.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

Sir Edward Thomason, being balloted for, was not elected into the Society.

"Investigation of New Series for the Rectification of the Circle." By James Thomson, LL.D., Professor of Mathematics in the University of Glasgow. Communicated by Francis Baily, Esq., V.P. and Treasurer R.S.

The author obtains formulæ by which the ratio of the circumference of a circle to its diameter may be computed with much greater facility and expedition than by any of the ordinary methods.

A paper was also in part read, entitled, "Inquiries respecting the Constitution of Salts, of Oxalates, Nitrates, Phosphates, Sulphates, and Chlorides." By Thomas Graham, Esq., F.R.S. Ed., Professor of Chemistry in the Andersonian University of Glasgow, &c. &c. Communicated by Richard Phillips, Esq., F.R.S.

Report upon a Letter addressed by M. LE BARON DE HUMBOLDT to HIS ROYAL HIGHNESS the PRESIDENT of the ROYAL SOCIETY, and communicated by His Royal Highness to the Council.

To His Royal Highness the President and Council of the Royal Society.

PREVIOUSLY to offering any opinion on the important communication on which we have been called upon to report, we feel that it will be proper to lay before the Council a full account of the communication itself. In this letter M. de Humboldt developes a plan for the observation of the Phenomena of Terrestrial Magnetism worthy of the great and philosophic mind whence it has emanated, and one from which may be anticipated the establishment of the theory of these phenomena.

After his return from the equinoctial regions of America, M. de Humboldt, in the years 1806 and 1807, entered upon a careful and minute examination of the course of the diurnal variation of the needle. He was struck, he informs us, in verifying the ordinary regularity of the nocturnal period, with the frequency of perturbations, and, above all, of those oscillations, exceeding the divisions of his scale, which were repeated frequently at the same hours before sunrise. These eccentricities of the needle, of which a certain periodicity has been confirmed by M. Kupffer, appeared to M. de Humboldt to be the effect of a reaction from the interior towards the surface of the globe—he ventures to say, of "*magnetic storms*"—which indicated a rapid change of tension. From that time he was anxious to establish to the east and to the west of the meridian of Berlin, apparatus similar to his own, in order to obtain corresponding observations made at great distances at the same hours, but was for a long period prevented putting his plan into execution by the disturbed state of Germany and his departure for France.

The Baron de Humboldt and MM. Arago and Kupffer having, by the cooperation of many zealous observers, succeeded in establishing permanent magnetic stations extending from Paris to China, M. de Humboldt solicits, through His Royal Highness the President, the powerful influence of the Royal Society in extending the plan, by the establishment of new stations. The plan which he proposes, and which has been successfully carried into execution over a large portion of the north-eastern continent, is that magnetical observations, whether of the direction of the horizontal and inclined needles, or for the determination of the variations of the magnetic force,

should be made simultaneously at all stations, at short intervals of time, for a certain number of hours and at fixed periods of the year, precisely similar to the plan which has been recommended and adopted by Sir John Herschel with reference to observations of the barometer and thermometer.

Referring in terms of commendation to the magnetical observations which have originated in this country, M. de Humboldt expresses his wish that such observations may, by the adoption of an uniform plan, and by connecting them with the observations now in progress on the continent of Europe and of Northern Asia, be rendered more proper for the manifestation of great physical laws. He then enters into a historical detail of the establishment of stations for magnetical observations, stating the important results obtained by M.M. Arago and Kupffer by means of simultaneous observations, which appear to establish the isochronism of the perturbations of the needle at Paris and Kasan, stations separated by 47° of longitude. Under the patronage of the Governments of France, of Prussia, of Denmark, and of Russia, magnetical observatories have been established at Paris, at Berlin, in the mines of Freyberg, at Copenhagen, in Iceland, at St. Petersburg, Kasan, Moscow, Barnoul at the foot of the Altai Chain, Nertschinsk near the frontiers of China, even at Pekin, and at Nicolajeff in Crimea.

M. de Humboldt states that the lines representing the horary variations at Berlin, Freyberg, Petersburg, and Nicolajeff affect parallelism, notwithstanding the great separation of the stations and the influence of extraordinary perturbations; that this, however, is not invariable, since even at small distances, for example, at Berlin and in the mines of Freyberg, one of the needles may show considerable perturbations, while the other continues that regular course which is a function of the solar time of the place.

The epochs at which it had been proposed that simultaneous observations should be made at all stations were,

20th and 21st of March
4th and 5th of May,
21st and 22nd of June,
6th and 7th of August,
23rd and 24th of September,
5th and 6th of November,
21st and 22nd of December,

} from 4 o'clock in the morning
of the first day, until midnight of
the second, observing, at least
hourly, night, and day, at each
magnetic station.

But as many observers have considered these as too near to each other, the observations most to be insisted upon are those at the times of the solstices and equinoxes.

England from the times of Gilbert, Graham, and Halley to the present, observes M. de Humboldt, has afforded a copious collection of materials, adapted to the discovery of the physical laws which govern the changes of the variation, whether at the same place, according to the hours of the day and the seasons of the year, or at different distances from the magnetic equator and from the lines of no variation. After adverting to the continued observations of

Gilpin and of Beaufoy, omitting however to mention the important ones by Canton, he observes that the arctic expeditions have furnished a rich harvest of important observations to Captains Sabine, Franklin, Parry, Foster, Beechey, and James Ross, and Lieutenant Hood*; and that thus physical geography is indebted to the attempts which have been made to discover the north-west passage, and also to the explorations of the icy coast of Asia, by Wrangel, Lutke, and Anjou, for a considerable accession of knowledge in terrestrial magnetism and meteorology. Excited, he observes, by the great discoveries of Oersted, Arago, Ampere, Seebeck, and Faraday, MM. Hansteen, Due and Adolphe Erman have explored, in the whole of the immense extent of Northern Asia, the course of the isoclinical, isogonal, and isodynamic curves; and M. Adolphe Erman has had the advantage during a long voyage from Kamtschatka round Cape Horn to Europe, of observing the three manifestations of terrestrial magnetism on the surface of the earth, with the same instruments and by the same methods which he had employed from Berlin to the mouth of the Obi, and thence to the sea of Okhotsk.

M. de Humboldt remarks that our epoch, marked by great discoveries in optics, electricity, and magnetism, is characterized by the possibility of connecting phenomena by the generalization of empirical laws, and by the mutual assistance rendered by sciences which had long remained isolated. Now, he observes, simple observations of horary variation or of magnetic intensity made at places far distant from each other, reveal to us what passes at great depths in the interior of our planet or in the upper regions of our atmosphere: those luminous emanations, those polar explosions which accompany the "*magnetic storm*" appear to succeed the changes which the mean or ordinary tension of terrestrial magnetism undergoes.

M. de Humboldt considers that it deeply interests the advancement of mathematical and physical sciences that, under the auspices of His Royal Highness the President, the Royal Society should exert its influence in extending the line of simultaneous observations, and in establishing permanent magnetic stations in the tropical regions on both sides of the magnetic equator, in high southern latitudes, and in Canada. He proposes this last station because the observations of horary variation in the vast extent of the United States are yet extremely rare. Those at Salem, calculated by Mr. Bowditch, and compared by Arago with the observations of Cassini, Gilpin, and Beaufoy, may, he remarks, guide the observers in Canada, in examining whether there, contrary to what takes place in Western Europe, the (diurnal?) variation does not decrease in the interval between the vernal equinox and the summer solstice.

In a memoir published five years ago, M. de Humboldt states that he has indicated as stations extremely favourable for the advancement of our knowledge, New Holland, Ceylon, the Mauritius, the

* To this long list we may now add the name of Captain Back; nor ought the name of Mr. Fisher to be omitted.

Cape of Good Hope, the Island of St. Helena, some point on the Eastern Coast of South America, and Quebec. In order, he observes, to advance rapidly the theory of the phenomena of terrestrial magnetism, or at least to establish with more precision empirical laws, we ought to extend and, at the same time, to vary the lines of corresponding observations; to distinguish, in the observations of the horary variations, what is due to the influence of the seasons, to a clear or a cloudy atmosphere, to abundant rains, to the hour of the day or night solar time, that is, to the influence of the sun, and what is isochronous under different meridians: we ought, in addition to these observations of the horary variation, to observe the annual course of the absolute variation, of the inclination of the needle and of the intensity of the magnetic forces, of which the increase from the magnetic equator to the poles is unequal in the American or Western, and in the Asiatic or Eastern hemisphere. All these data, the indispensable basis of a future theory, can acquire certainty and importance only by means of fixed establishments, which are permanent for a great number of years, observatories in which are repeated, at settled intervals and with similar instruments, observations for the determination of numerical elements.

Travellers, remarks M. de Humboldt, who traverse a country in a single direction and at a single epoch, furnish only the first preparations for labours which ought to embrace the complete course of the lines of no variation; the progressive displacement of the nodes of the magnetic and terrestrial equators; the changes in the forms of the isogonal and isodynamic lines; and the influence which, unquestionably, the configuration and articulation of the continents exert upon the slow or rapid march of these curves. He will, he considers, be fortunate if the isolated attempts of travellers, whose cause he has to plead, have contributed to vivify a species of research which must be the work of centuries, and which requires at once the cooperation of many observers, distributed in accordance with a well-digested plan, and a direction emanating from many great scientific centres of Europe; this direction, however, not being for ever restricted by the same instructions, but varying them according to the progressive state of physical knowledge and the improvements which may have been made in instruments and the methods of observation.

In begging His Royal Highness the President to communicate this letter to the Royal Society, the Baron de Humboldt disclaims any intention of examining which are the magnetic stations that at the present time deserve the preference, and which local circumstances may admit of being established. It is sufficient that he has solicited the cooperation of the Royal Society to give new life to a useful undertaking in which he has for many years been engaged. Should the proposition meet with their concurrence, he begs that the Royal Society will enter into direct communication with the Royal Society of Göttingen, the Royal Institute of France, and the Imperial Academy of Russia, to adopt the most proper measures to combine what is proposed to be established with what already exists;

and adds, that, perhaps, they would also previously concert upon the mode of publication of partial observations and of mean results.

M. de Humboldt finally refers to the labours and accurate observations of M. Gauss at the Observatory of Göttingen. The methods, however, adopted by M. Gauss being already before the Royal Society in a memoir which has been communicated by him, renders it unnecessary here to enter into the explanation given of them by M. de Humboldt. He has referred to them in order that those members of the Royal Society who have most advanced the study of terrestrial magnetism, and who are acquainted with the localities of colonial establishments, may take into consideration, whether, in the new stations to be established, a bar of great weight furnished with a mirror should be employed, or whether Gambey's needle should be used: his wish is only to see the lines of magnetic stations extended, by whatever means the precision of the observations may be attained.

M. de Humboldt concludes by begging His Royal Highness to excuse the extent of his communication. He considered it would be advantageous to unite under a single point of view what has been done or prepared in different countries towards attaining the object of great simultaneous operations for the discovery of the laws of terrestrial magnetism.

Having very fully laid before the Council the contents of M. de Humboldt's letter, we have now to offer our opinion upon the subject it embraces. There can, we consider, be no question of the importance of the plan of observation which is here proposed for the investigation of the phenomena of terrestrial magnetism, or of the prospect which such a plan holds out of the ultimate discovery of the laws by which those phenomena are governed. Although the most striking of these phenomena have now been known for two centuries, although careful observations of them have within that period been made, and that still more care and attention have been bestowed upon those more recently discovered, yet the accessions to our knowledge, not only regarding the cause of the phenomena, but even with respect to the laws which connect them, bears a very small proportion to the mass of observations which have been made. This has arisen in a great measure, if not wholly, from the imperfection of the data from which attempts have been made to draw conclusions. Whatever theories may have been advanced in explanation of these phenomena, or attempts made to connect them by empirical laws, still, whenever comparisons have been instituted between the results of observation and such theories or laws, it has, in general, been doubtful whether the discrepancies which have been found might not as justly be attributed to errors in the observations, as to fallacies in the theory or incorrectness in the laws. Under these circumstances, the Royal Society, as a society for the promotion of natural knowledge, cannot but hail with satisfaction a proposition for carrying on observations of phenomena most interesting in their nature and most obscure in their laws, in a manner that

shall not only give greater precision to the observations, but at the same time render all the results strictly comparative.

There are, however, other grounds on which such a proposition as that made by M. de Humboldt should be most cordially received by the Royal Society. This Society is here called upon, as a member of a great confederation, to cooperate with several other members, already in active cooperation, for the attainment of an object which ought to be common to all; and to such a call the Royal Society can never be deaf. Those who know best what has been done by cooperation on a well-digested system, and what remains undone in many departments of science for the want of it, can best appreciate the benefits that would accrue to science, by the adoption of the extensive plan of cooperation advocated by M. de Humboldt. Independently of our acquiring a knowledge of the laws which govern the phenomena here proposed to be observed, we ought to look to the effect which the adoption of such a plan may have on other branches of science. The example being thus once set of extensive cooperation in a single department of science, we may anticipate that it would be eagerly adopted in others, where, although our knowledge may be in a much more advanced state than it is regarding the phenomena of terrestrial magnetism, still much remains to be accomplished, which can scarcely be effected by any other means. We might thus hope to see the united efforts of all the scientific societies in Europe directed to the prosecution of inquiry, in each department of science, according to the plan of cooperation best adapted for its development.

We must now, after these remarks on the general bearing of M. de Humboldt's communication, go somewhat into detail on points connected with it. One point of view in which we consider the proposed plan of great importance, and to which M. de Humboldt has not expressly referred, is this. However defective ordinary dipping instruments may be considered to be, there are few persons who have had opportunities either of making observations with the ordinary instruments for determining the variation of the needle, or of comparing those made by others by the usual methods with such instruments, who will not admit that these instruments and methods are fully as defective—possibly much more so. Thus, however we may multiply the points on the earth's surface at which such observations may be made, still great uncertainty must always rest upon such determinations of these two important elements; and in all comparisons of such observations with laws, whether empirical or deduced from theory, it will ever be doubtful whether the discordances which may be found are due to errors of observation, or are indicative of the fallacy of these laws. This source of uncertainty must, in a great measure, if not wholly, be obviated by observations made at fixed stations, with instruments of similar construction, which have been carefully compared with each other. And we have no hesitation in stating our opinion that more would be done in determining the positions of the poles of convergence and of verticity on the earth's surface and other points, most important

towards the establishment of anything like a theory of terrestrial magnetism, by simultaneous observations made at a few well-chosen fixed stations, than by an almost indefinite multiplication of observations by the ordinary methods.

That a magnetic chart that should correctly exhibit the several lines of equal variation, Humboldt's "Isogonal Lines", would be of the greatest advantage to navigation, those who are best qualified to judge are most ready to admit. If to these lines were added the isoclinal lines, or lines of equal dip, the value of such a chart would, for the purposes of navigation in particular, be greatly enhanced. Whatever may be the magnitude of the influence of the iron in a ship on its compass needle, the extent of the deviation of the horizontal needle due to that influence, on any bearing of the ship's head, is a function of that bearing and of the dip of the needle at the place of observation. The extent, therefore, of the horizontal deviations, in various bearings of the ship's head, having been ascertained at any port where the dip of the needle is known, their extent at any other place, however distant, at which the dip is also known, may readily be calculated. Consequently a chart which should correctly exhibit the isoclinal, in conjunction with the isogonal, lines, would readily furnish the means of obtaining the correction to be applied to the ship's course by compass, both for the variation of the needle and for the deviation due to the ship's influence upon its compass. Whatever charts of this description may have already been constructed, and whatever materials may exist for the construction of more accurate ones, it is well known that great discrepancies exist among the data requisite for such constructions. And it appears to us that such a careful inquiry into the whole of the phenomena of terrestrial magnetism as is proposed by M. de Humboldt, is the means best adapted to ensure the accuracy which would be of such inestimable advantage in this most useful application of scientific knowledge.

Although our views with regard to the stations proper to be selected for permanent magnetical observatories in general accord with those expressed by M. de Humboldt, we shall, we consider, be only conforming to his wishes, if we point out those stations which, from particular circumstances of position, appear most desirable. We consider that it would be of the greatest advantage if two or more permanent magnetical observatories were established in the high latitudes of North America, on account of the proximity of stations so situated to the northern magnetic poles of convergence and verticity, whether these poles are two different points or one and the same: indeed, continued observations at such stations would go far to decide this question, highly important in a theoretical point of view. M. de Humboldt has mentioned Quebec as a desirable station. To this place, and also to Montreal, we conceive that an objection exists, of which possibly M. de Humboldt is not aware: many of the houses in those cities are roofed with tinned iron. This objection may not, however, exist in some of the establishments in the vicinity of either of these cities. We consider

that the most advantageous positions would be, one near the most northerly establishments in Hudson's Bay, and another at or near to Fort Resolution on Great Slave Lake. As, however, observers in such positions would be placed almost beyond the pale of civilization, we fear that, for some time at least, it will be found quite impracticable to obtain regular observations at these important stations. It would likewise be desirable that there should be a station in Nova Scotia or Newfoundland: the latter would be the preferable position.

If the Government of the United States were to give their cordial cooperation to M. de Humboldt's plan, by the establishment of three or more permanent magnetical observatories, in different longitudes, these, with what we may expect to be undertaken by Russia in the extreme north-west, and our own establishments, would afford the means of obtaining a mass of more interesting magnetical observations than could perhaps be derived from any other portion of the earth's surface.

M. de Humboldt mentions New Holland, Ceylon, the Mauritius, the Cape of Good Hope, St. Helena, and a point on the east coast of South America, as desirable stations, and we fully concur in the propriety of the selection. Although Van Diemen's Land, from its greater proximity to the southern magnetic pole, would be a more advantageous position for magnetical observations than Paramatta, yet the circumstance alone of there being an astronomical observatory established at Paramatta, renders it peculiarly adapted for a magnetical station. Possibly circumstances may hereafter admit of magnetical observations being also made at Hobart Town, in conformity with the general plan which may be adopted.

The Island of Ascension, from its proximity to the magnetic equator, would possess peculiar advantages for a magnetical station; but these must, in a great degree, be counterbalanced by the nature of its soil, which, being wholly volcanic, would exert an influence on the needle that would render observations made there of a doubtful character: indeed, the same objection applies to St. Helena and most of the islands of the Atlantic. Some recent observations, those of Lieut. Allen, R.N., in the expedition up the Niger, would point to the Bight of Benin as a desirable station; but the insalubrity of the climate and other circumstances prevent our recommending its adoption.

M. de Humboldt has not referred to any station in our West Indian colonies, but we consider that circumstances point to Jamaica as a station where it is very desirable that accurate magnetical observations should be made. It is generally considered that the variation there has, for a very long period, undergone but little change; and, on this account alone, it would be very desirable to ascertain, with precision, the amount of the variation, so that hereafter the nature of the changes it may undergo may be accurately determined. Its position also, with reference to the magnetic equator, is one which would recommend it as a magnetical station*.

* Mr. Pentland, who has been appointed Consul-General to the Republic of Bolivia, having, since the Baron de Humboldt's letter was referred to us,

Although M. de Humboldt has not adverted to any other point besides Ceylon in our Indian possessions, yet no doubt he would, with us, consider it desirable that observatories should be established at different points on the continent of India; and it appears to us that Calcutta and Agra are in positions well adapted for the purpose. As, however, there is an Astronomical Observatory established at Madras, there would be greater facility in obtaining magnetical observations there than at places where no such establishment exists. We feel assured that the East India Company, which has shown so much zeal and liberality in the promotion of scientific inquiry, and such a desire for the advancement of scientific knowledge in the extensive possessions under its controul, would afford its powerful assistance in the establishment of observatories for the investigation and determination of the laws of phenomena intimately connected with navigation, and, consequently, with the commercial prosperity of our country.

We consider, also, that Gibraltar and some one of the Ionian Islands are very desirable stations for the establishment of permanent magnetical observatories; and, to come nearer home, that such observatories should be established in the North of Scotland and in the West of Ireland.

M. de Humboldt adverts to another very interesting class of magnetical observations, those in the mines of Freyberg. The mines of Cornwall from their great depth, some being 1200 feet below the level of the sea, are peculiarly well adapted for observations of this description; and, from the spirit with which philosophical inquiry has been carried on in that part of England, we do not anticipate that much difficulty would occur in the establishment of a magnetical station in one of these mines.

Having enumerated the stations which by their position appear best adapted to furnish valuable results, and having likewise pointed out the facilities which some afford for the execution of this plan of observation, immediately that the nature of the instruments to be employed has been determined upon, and that such instruments can be provided, it may be proper to advert to stations where, although the same facilities do not exist, we consider that zealous and able observers might be obtained without much difficulty. We conceive that such is the case in Newfoundland, in Canada, at Halifax, Gibraltar, in the Ionian Islands, at St. Helena, and Ceylon; and we have authority for stating that there would be no difficulty in obtaining observers in the Mauritius, and even at the colony on the

offered his earnest cooperation in the objects contemplated in that letter, we cannot hesitate, now that this has been communicated to us, to recommend that an offer so liberal should be made available to science. If accurate magnetical observations were made at some station on the elevated table-land of Mexico, and simultaneously at another not very distant station, nearly at the level of the sea, we consider that they would determine points relative to the influence of elevation on the diurnal variation, the dip and intensity, respecting which our information is at present, to say the least, extremely deficient.

Swan River, the latter being a most desirable station. We have not alluded to the observatory at the Cape of Good Hope; if however no such establishment existed, the presence of Sir John Herschel would ensure cooperation there, in any plan calculated to advance scientific knowledge. Thus, altogether, there might be formed a most extensive spread of stations, in which the principal expense would consist in the purchase of the requisite instruments; and the means of establishing stations where the same facilities do not exist might afterwards be taken into consideration. As it would be necessary that, at all the stations, observations of the barometer, thermometer, and of atmospheric phenomena should be made simultaneously with the magnetical observations, these would altogether form a mass of valuable meteorological information which it would be scarcely possible to collect by any other means.

There is one point in M. de Humboldt's communication on which we have not yet touched: the nature of the instruments best calculated to attain the objects in view by the establishment of magnetical observatories. This is a subject on which it will be most proper to enter fully when their establishment has been determined upon; and we would recommend that then a Committee should be appointed to investigate the subject, and that this Committee should report to the Council of the Royal Society what instruments they consider it would be most advisable to adopt at all the stations, and, at the same time, give in an estimate of the expense that must be incurred for one complete set of such instruments. We may, however, in the mean time, offer a remark on one apparatus referred to by M. de Humboldt, that of M. Gauss. However well we may consider this apparatus to be adapted for the determination of the course of the regular diurnal variation, yet we apprehend that the great weight of the needles employed would prevent their recording the sudden and extraordinary changes in the direction of the magnetic forces, which are, probably, due to atmospheric changes. Another, and we conceive a very serious objection to this apparatus is, that bars of the magnitude employed must have an influence so widely extended, that there would be great risk of the interference of one of these heavy needles with the direction of another, especially in places where the horizontal directive force is greatly diminished, unless the rooms for observation were placed at inconvenient distances from each other.

By referring to M. de Humboldt's letter, it will be seen that the plan of observation so comprehensively conceived by him, has been most powerfully and liberally patronized by the Governments of France, of Prussia, of Hanover, of Denmark, and of Russia: indeed, it is quite manifest that a plan so extensive in its nature must be far beyond the means of individuals, and even of scientific societies unaided by the governments under which they flourish. To suppose, even without the example thus held out, that the Government of this, the first maritime and commercial nation of the globe, should hesitate to patronize an undertaking, which, independently of the accessions it must bring to science, is intimately connected with na-

vigation, would imply that our Government is not alive either to the interests or to the scientific character of the country, and would show that we had little attended to the history, even in our own times, of scientific research, which has been so liberally promoted by the Government. Although the investigation of the phenomena of terrestrial magnetism was not the primary object of the expeditions which have now, almost uninterruptedly, for twenty years been fitted out by Government,—another of which, and one of the highest interest, is on the point of departure,—yet a greater accession of observations of those phenomena has been derived from these expeditions than from any other source in the same period. We therefore feel assured that, when it shall have been represented to the Government that the plan of observation advocated by the Baron de Humboldt is eminently calculated to advance our knowledge of the laws which govern some of the most interesting phenomena in physical science; it appears to be perhaps the only one by which we can hope ultimately to discover the cause of these phenomena; and that, from it, results highly important to navigation may be anticipated—that the patronage to the undertaking which is so essential to its prosecution will be most readily accorded. We beg, therefore, most respectfully, but at the same time most earnestly, to recommend to His Royal Highness the President and to the Council, that such a representation be made to the Government, in order that means may be ensured for the establishment, in the first instance, of magnetical observatories in those places which, from local or other causes, afford the greatest facilities for the early commencement of these observations.

S. HUNTER CHRISTIE.
G. B. AIRY.

9th June, 1836.

November 30, 1836.

At the Anniversary Meeting of the Royal Society, H.R.H. the Duke of Sussex, K.G., President, in the Chair,

William Hasledine Pepys, Esq., one of the Auditors on the part of the Society, reported, that the balance in the Treasurer's hands at the recent Audit was £533. 4s. 11d.: and that the statement of the receipts and payments was laid on the table for the inspection of the Fellows.

The Thanks of the Society were voted to the Auditors for their trouble in auditing the Treasurer's Accounts.

The following Lists of the Fellows admitted, and of those deceased during the past year, were read :

Admitted.—George Biddell Airy, Esq., A.R.; Robert Alexander, Esq.; David Baillie, Esq.; Richard Beamish, Esq.; George Budd, A.B. and M.; Major T. Seymour Burt; Edward Burton, Esq.; Dr. William Clark; John Green Cross, Esq.; Captain John James Chapman, R.A.; William Sands Cox, Esq.; George William Drory, Esq.; Charles Elliott, Esq.; G. W. Featherstonhaugh, Esq.;

Joshua Field, Esq.; Robert Edmund Grant, M.D.; Rev. William B. L. Hawkins, M.A.; Edward John Johnson, Captain R.N.; John D. Llewelyn, Esq.; Captain Thomas Locke Lewis, R.E.; Rev. Humphrey Lloyd, M.A.; Francis Marcet, Esq.; Sir William Molesworth, Bart.; Earl of Minto; Moses Montefiore, Esq.; Dr. Archibald Robertson; the Rev. William Taylor; Charles Wheatstone, Esq.

Deceased : on the Home List.—John Bell, Esq.; William Blane, Esq.; Richard Blanshard, Esq.; the Right Honourable Reginald Pole Carew; Lewis Andrew de la Chaumette, Esq.; Lord Bishop of Ely; Sir William Gell; Dr. Gillies; William Henry, M.D.; James Horsburgh, Esq.; David Hosack, M.D.; William Lax, Esq.; William E. Leach, M.D.; William Marsden, Esq.; William M. Pitt, Esq.; John Pond, Esq.; Richard Saumarez, Esq.; Sir John Sinclair, Bart.; Rev. G. A. Thursby; Pelham Warren, M.D.; William R. Whetton, Esq.; Sir Charles Wilkins, K.H.; Grant David Yeats, M.D.

On the Foreign List.—Monsieur Ampère; Monsieur Jussieu.

His Royal Highness the President, then addressed the Society in the following words:—

GENTLEMEN,

I APPEAR before you, after an absence of two years from this chair, under circumstances which deeply affect my feelings. I have been secluded, during nearly the whole of that period, from the active business of life and of society, by the slow but sure approaches of almost total blindness; by preparations for a most delicate and, to me, most important operation, and by the precautions which were necessary to accomplish my recovery, after it had been most skilfully and successfully performed. In resuming now, therefore, my public duties in this place, I feel sensibly the novelty of my situation, as if I were entering, by the blessing of God, upon a new tenure of existence, which, whilst it offers to my view many prospects of happiness, imposes upon me likewise heavy responsibilities; and I can only express my fervent hope and prayer, that the same merciful Providence which has vouchsafed, through his appointed means, to restore me to sight, may enable me, like a willing and humble-minded scholar, to apply the lessons taught me by the experience of my past life, to the just and useful regulation of that portion of my course which I may be still permitted to run.

It is my first and most pleasing duty, Gentlemen, to thank you for your congratulations upon my recovery, which have been conveyed to me in terms most grateful to my feelings. I have on many occasions experienced both your kindness and forbearance, and I deeply regret that circumstances should so frequently have compelled me to appeal to them: but at no moment could the expression of your good-will be more welcome to me than at the present, when I am enabled to reappear amongst you, upon being again entrusted with the possession of that blessing, the value of which I have learnt to appreciate more fully by my experience of its privation.

Could I have foreseen, when the progress of my malady first removed me from public life, the length of time which was to elapse before its termination, even in case I could have felt assured that it would end as fortunately as it has for me, I would not have ventured to trespass, so long as I have done, upon your indulgence, but would at once have retired from the proud situation of your President; for though I could rely with perfect confidence upon the cordial cooperation of the members of the Council, and should have felt satisfied that they would not allow the real interests of the Society to suffer from my absence, yet I could not have continued altogether free from alarm, lest its dignity should be lowered in public estimation, were its affairs long allowed to be conducted with an incomplete establishment; or the becoming authority of this Chair should be lessened by frequent changes in its occupation, particularly on great and public occasions. I was always led to believe that the disease under which I laboured would have been sufficiently advanced to justify an operation much sooner than eventually proved to be the case, and I was therefore induced to hope that my absence from the Society would not have been prolonged for such a period as to be productive either of reasonable complaint, or of serious inconvenience. When, however, the day of your last Anniversary approached, and that hope had proved delusive, I felt it my duty to resign my trust, however reluctant to sever myself from a body with which I am so honourably connected; and I only consented to continue in its occupation, when kindly pressed to do so by the members of the Council, under the conviction that the time for performing the operation was so near at hand, that its success or failure would speedily decide whether I should be capable of again taking an active part in our concerns, or be compelled to terminate my official connexion with you for ever. I thank God that I am now enabled, in person, to express my heartfelt gratitude for your kindness to me on all occasions, and especially on the present; and I beg you to feel assured that the remembrance of your sympathy with my affliction whilst it continued, and of your warm congratulations upon my happy recovery, will ever tend to cement more closely the ties of affection and friendship which subsist between me and the Fellows of the Royal Society.

My necessary absence from my duties amongst you will prevent my entering in much detail upon the ordinary transactions of the Council, and of our weekly meetings during the last year; for a particular statement of which I must refer to the Report of the Council, which will be read to you by one of your Secretaries, Dr. Roget. There are only two topics connected with them to which I feel myself particularly called upon to allude.

The first is the publication of the classed catalogue of our library; the second relates to the discussions which have been attempted to be raised upon the Minutes of your proceedings on the ordinary days of your assembling during the last year.

It is well known to you, Gentlemen, that, after the transfer

of the Arundelian MSS. to the British Museum, and the great additions which your library received from purchases and exchanges of books, necessarily consequent upon that transaction, Mr. Panizzi was employed by the Council to draw up a classed catalogue of its contents. Such a compilation it was considered would be of great value, not merely to the Fellows of the Society but to men of science generally, by making known to them the treasures of a library singularly rich and complete in journals, and works on mathematical, physical, astronomical, and anatomical science, and by presenting them in such a form that persons engaged in works of research, or in any specific subject of scientific inquiry, might be made at once acquainted with nearly all the sources from whence they could derive information. This catalogue is now printed, or more correctly speaking, *composed*, and is undergoing such a revision from different Members of the Council, who have kindly undertaken this task, as is calculated to make it as correct and complete as the circumstances of the case will allow it to be. I have reason to hope that this work will be shortly placed in the hands of the Fellows, and that the example which it will present of what may be accomplished by the exertions of a learned body with very limited funds at its command, will not be without its influence in hastening the completion of a similar work with respect to our great national library, upon a scale proportionate to its importance, and worthy of a great and wealthy people, amongst whom literature, science, and the arts are duly cultivated and pursued.

The discussions that have at different times during the last year been raised upon the Minutes of your proceedings, constitute the second subject which I wish especially to notice.

I am quite sure, Gentlemen, that you will agree with me in thinking, that no one circumstance has contributed so effectually to maintain the dignity of the Royal Society, as the prohibition of personal debate in the transaction of its ordinary business; and if I wished for any additional confirmation of this opinion, I would appeal to the very serious amount of irritation which it produced amongst you in the course of the last year, though originating in the most trivial causes. It was chiefly with a view to avoid inconveniences of this kind, and to provide an outlet for the proper expression of opinion, when any just occasion of complaint might exist, or any extraordinary circumstance occur, and to terminate disputes whenever unfortunately they might arise, that the Council, at the last revision of our statutes, passed a by-law, as they were fully authorized to do, which makes it imperative upon the President and Council to call an extraordinary meeting of its Members, upon the due presentation of a requisition for that purpose, signed by at least six Fellows, and setting forth, in specific terms, the objects for which it was required to be summoned, provided those objects be not inconsistent with the charter and statutes of the Society. Such extraordinary meetings being strictly domestic, and confined to the Fellows of the Society only, appear to me not merely to offer a sufficient security against any great mismanagement of the affairs of

the establishment, but likewise to protect your ordinary meetings from those irregular and somewhat tumultuary discussions on matters of business, or personal conduct, which might otherwise be in danger of arising.

I believe that many persons have expressed a wish that the regulations of this Society should be so far relaxed as to allow, in conformity with the practice of some other similar establishments, discussions upon the papers, and those papers only, which are read before us: I confess, for my own part, that I am not at present prepared to accede to this recommendation. A practice which has been sanctioned by the usage of more than a century and a half, and found to be productive of scientific results unrivalled for their extent and value, should not be abandoned by us without the most mature consideration; and though I am the last person to recommend a slavish submission to the dictates or to the customs of antiquity, which may be unsuited either to the altered circumstances of modern times, or incapable of defence upon other and independent grounds, yet a reverence is justly due both to maxims and observances which have been sanctioned by high authorities, or connected with great and important public benefits. It may be quite true that such discussions would tend materially to increase the personal interest which is taken, by many of our members, in our proceedings; but when we consider the abstract and abstruse nature of many of the papers which come before us, and which no single reading can make perfectly intelligible, even to the best-instructed hearer, as well as the vast variety of subjects which they comprehend, I think we may fairly infer that such discussions would rarely add much to the stock of facts or of reasonings which they contain, or that their influence would be materially felt in the publications of your Transactions, which have always formed, and which ought always to form, the great object of the foundation of this Society, and the only means by which its character and influence can continue to be maintained unimpaired throughout the civilized world. When we likewise take into further consideration the irregularities and personalities to which such debates would on some occasions give rise, unless very strictly limited and very authoritatively controlled, as well as the indirect influence which the premature expression of opinions upon the contents and merits of individual papers might exercise upon the decision of the Council in selecting them for publication, you will be disposed to agree with me, I trust, in thinking that such an experiment would be at least dangerous to the peace, as it very possibly might prove ultimately injurious to the scientific character, of the Royal Society.

But let me not be misunderstood: the success that has attended this practice in the institution which has contributed so powerfully to the rapid advance of a highly popular science, might appear to offer a practical refutation of such grounds of alarm as those which I have ventured to suggest; but the cases of the two Societies are extremely different. The science of geology is eminently a science of observation, where facts, collected from all quarters of the globe,

and accurately recorded, possess a value which is in many cases independent of the theoretical inferences that may be deduced from them: it is a science which disdains not the aid of the humblest labourers who can widen the range of its observations; it is a science also in which both facts and theories can be communicated more accurately and more rapidly by a graphic and vivid oral description, aided by an immediate reference to maps, drawings and specimens, than by the most elaborate and laborious written descriptions; it is a science which can only be learnt by being seen, and which can only be seen through ten thousand eyes. In all these, and in many other important particulars, it differs from the majority of those sciences which most commonly come under the notice of the Royal Society; and the many circumstances which not only justify, but in some degree render necessary, the discussions upon the papers read, or the facts communicated to the Geological Society, would almost entirely cease to apply if extended to us. And when we further consider the varied knowledge and accomplishments, the lively wit and rare eloquence of many of those distinguished men who usually take part in those debates, and who are themselves the highest authorities in the very science which on such occasions they are called upon to illustrate and to teach, we should be disposed rather to regard them as lectures delivered by great masters to pupils who come to learn, than as the discourses of philosophers, amongst each other, upon the more abstract and less attractive departments of human knowledge.

And now, Gentlemen, before I conclude this portion of my address, there remains but one other point which I think it my duty to notice. A trust of great importance, imposed on the President of the Royal Society by the will of the last Earl of Bridgewater, the most onerous and responsible duties of which devolved upon my worthy friend and predecessor Mr. Davies Gilbert, is at length terminated, by the appearance, which has been long and anxiously expected, of the eighth Treatise of the series. It would ill become me to speak of the mode in which that important duty was discharged by him, or of the principles which guided himself and his distinguished assessors, in the selection either of subjects or of the authors; but a list which is headed by the name of Whewell and closed by that of Buckland, can hardly be considered as an unworthy representation of the science and literature of this country.

Amongst the losses sustained by the Society during the last year, will be found many names of persons distinguished for their services both in literature and in science; and if we might be allowed to form a judgement from the very great proportion of these eminent men whose ages have approached the extreme limits of human life, we might conclude with great confidence that the most severe studies and the most trying climates, if pursued with temperance or guarded against with care, are not unfavourable either to health or longevity. The list which has been placed in my hands contains the names of twenty-one Fellows and two Foreign Members, and I greatly regret that the notice which I am enabled to take of some of the most

distinguished of their number should be necessarily so slight and imperfect.

Mr. Pond succeeded Dr. Maskelyne as Astronomer Royal in 1810, and retired from that important situation, under the pressure of many infirmities, in the autumn of last year: he was formerly a member of Trinity College, Cambridge, where he was a pupil of Professor Lax, whose name appears also in the list of deaths which has been just read to you. After leaving the University, he travelled in many parts of the East, and particularly in Egypt, partly urged by the spirit of adventure which is natural to youth and partly with a view of making astronomical observations in climates more pure and more regular than our own. After his return home in 1800, he settled at Westbury, in Somersetshire, and devoted himself, amidst other pursuits, chiefly to astronomy, making use of a circular instrument of $2\frac{1}{2}$ feet diameter, which had been constructed and divided by Troughton with more than ordinary care. With this instrument he observed by a peculiar method, the declinations of some of the principal fixed stars, which were communicated to the Royal Society in 1806; and it afterwards enabled him to establish the fact of a change of form in the great quadrants at Greenwich, a discovery of great importance, inasmuch as it not only led to the substitution of circular instruments for them in our national observatory, but subsequently likewise to his own appointment as Astronomer Royal.

After Mr. Pond's establishment at Greenwich, he communicated to the Royal Society from time to time, not merely the general results of his labours, but likewise his views of the theory of astronomical observations and of the grounds of judging of their relative accuracy: his system was to observe differences of declination and right ascension, making every star a point of departure for the rest, and considering the pole as a point in the heavens whose position was capable of a determination, equally, and not more accurate than that of any given star. To such a view of the theory of observation, circular instruments were particularly adapted, and there is no reason to doubt that the relative catalogues of the stars which were formed by Mr. Pond were more accurate and complete than those of any preceding or cotemporary observer. Such a result, however, might have been reasonably expected from the great powers and resources of the establishment over which he presided and which he had himself been the chief means of calling into action.

The method which was adopted by Mr. Pond to determine the limits of the annual parallax of certain fixed stars by means of fixed telescopes of great focal length, was singularly ingenious and complete. The existence and amount of such a parallax had been asserted and assigned by Dr. Brinkley, in α Lyræ, α Aquilæ, and α Cygni; but this opinion, although most ingeniously and even obstinately vindicated and maintained by him, was, in the judgement of most other astronomers, most decisively negatived by Mr. Pond, who showed that the parallax of those fixed stars, supposing its amount to be sensible, was confined within the limits of the errors of the most delicate and perfect observations which have been hitherto made. There

is no great question in astronomy, the present position and limits of which are more satisfactorily settled.

Mr. Pond was remarkable for his skill and delicacy in the manipulation of his instruments, and no man was more capable of forming a correct judgement of their capacities and powers, and of the nature and extent of the errors to which they were liable: he was in the habit of placing great reliance on the results of a great number of observations, when no apparent or assignable cause existed for giving a determinate sign or character to the errors of individual observations: this confidence, however, was founded on his great knowledge of the theory of observation, and was fully justified by a comparison both of his own results with each other, and with those of other observers.

Mr. Pond was a man of gentle and amiable character, and singularly candid and unprejudiced. His health for many years before his death was greatly deranged, but he continued to struggle against the progress of his infirmities, and, from a conscientious feeling, he never abandoned the active duties of superintending the observatory, though hardly able to sustain them. He died in August last, at Lee, in Kent, and was buried in the tomb of his great predecessor Halley.

Mr. Pond, though a great practical astronomer and a man of uncommonly clear intellect and correct judgement, was deficient in one very considerable qualification for the station which he filled,—I mean, an acquaintance with the higher branches of Analysis, and their application to Physical Astronomy. His successor, Gentlemen, is well known to you, and needs no eulogium of mine; but I cannot omit the opportunity which is now offered to me of congratulating the friends of astronomy and of science on the appointment of a gentleman to this most important office, who is second to none in this country in his great attainments in almost every department of accurate science, in his indefatigable and systematic industry, in his high sense of public duty, and in his profound knowledge both of physical and of practical astronomy.

The names which I shall next bring before your notice are those of three men, venerable alike for their great age and public services, and who must always be regarded as entitled to hold a distinguished place amongst that illustrious body of great men, who have been produced or brought forward by the important trusts, the varied employments, and, let me add likewise, the great rewards of our Indian empire; I mean Sir Charles Wilkins, Mr. Marsden, and Captain Horsburgh.

Sir Charles Wilkins went to India in 1770, and was the first Englishman who thoroughly mastered the difficulties of the Sanscrit language, of the classical works in which he published several translations, and smoothed the obstacles to its attainment by a noble grammar, which he composed for the especial benefit of the students of the East India college at Haylebury, of which he was the oriental visitor and examiner from the period of its first establishment. He formed with his own hand the matrices of the first Bengali and Persian types which were used in Bengal, and he was the chief agent, in conjunction with Sir William Jones, in the esta-

blishment of the Asiatic Society of Calcutta, whose labours have contributed so greatly to the advancement of our knowledge of the languages and general condition of the provinces of our Eastern empire. It is now more than fifty years since he returned to this country, in possession of a competent fortune and vigorous health, which he continued to enjoy, in conjunction with every social and domestic comfort, with hardly any interruption, to the day of his death. Sir Charles Wilkins was appointed, in 1800, Librarian of the great collection of Oriental MSS., which are preserved in the India House; and this Society is indebted to him for the catalogue and description of the Sanscrit and other Oriental MSS., which were presented to it by Sir William and Lady Jones.

Sir Charles Wilkins was the father-in-law of Mr. Marsden, though nearly his cotemporary in age. They went to the East about the same time, and whilst one devoted himself to the study of the languages and literature of the ancient and modern inhabitants of continental India, the other availed himself of his position on the great island of Sumatra and the Malayan peninsula, to gain a thorough acquaintance with the present condition and past history of that active and adventurous race, whose character has been so deeply and so generally impressed upon the languages and customs of nearly all the tribes who inhabit the innumerable islands of the Indian Archipelago and of the Pacific Ocean. His account of Sumatra, which appeared soon after his return from the East, may be considered as a model for all monographs of the history, languages, customs, and statistics of a particular nation. He subsequently published a Malay dictionary of great authority and value; and in many separate memoirs, one of which appeared the year before his death, he traced with great learning and research the general characters and analogies of the East Insular and Polynesian languages, and proposed an alphabet for their uniform and intelligible transcription. Mr. Marsden was the author of four papers in our Transactions on some remarkable natural phenomena in the island of Sumatra, on the Mahometan æra of the Hejira, and on the chronological periods of the Hindoos; the two last of which show a very extensive acquaintance with Arabian and Hindoo literature. He published very elaborate catalogues of his fine collections of vocabularies and grammars, and also of his oriental coins; the first of which he presented in his life-time to King's College, London, and the second to the British Museum. Mr. Marsden returned to England from the East at an early age, and was Secretary to the Admiralty during the most eventful period of the late war. He continued to enjoy to an extreme old age, extraordinary vigour both of mind and body, equally respected and beloved for his great learning and very varied acquirements, for his independent and disinterested character, and for his many social and domestic virtues.

Captain James Horsburgh entered the sea service of the East India Company at a very early age, and in a very humble capacity, and raised himself by his perseverance, good conduct, and strong natural talents to the command of a ship, in which he was employed, for a considerable time, in a hydrographical survey of many of the coasts

and islands of the Indian and Chinese seas. It was soon after his return to Europe in 1805, that he communicated to this Society, through Mr. Cavendish, his very remarkable observations of the equatorial motions of the mercury in the barometer when at sea; and contributed along with Captain Flinders, both by these observations and by other directions which he subsequently published, to make more fully known the importance of barometrical observations at sea, as affording indications of great or sudden atmospheric changes. Captain Horsburgh was soon afterwards appointed Hydrographer to the East India Company, with the usual judgement, and discrimination of the Directors of that Body, in the selection and rewarding of their officers; and it was in this capacity that he published not merely a great number of charts, but also "the East India Sailing Directory," the result of the unremitting labour of many years, and founded partly upon his own observations, and partly upon a very accurate examination and reduction of the vast hydrographical records which are in the possession of the East India Company; forming altogether one of the most valuable contributions that was ever made by the labours of one man to the interests of navigation. Captain Horsburgh was the author of other works connected with his favourite science, and he continued to devote himself, until within a few days of his death, with almost unexampled industry, to those pursuits which had formed, throughout his whole life, the means by which he sought to benefit his countrymen and mankind.

Mr. William Blane was the author of a paper in our Transactions, written fifty years ago, on the production and preparation of Borax, which is brought from Jumlat in Thibet, over the Himalaya mountains into Hindostan.

Dr. David Hosack, of New York, was the author of a paper in our Transactions, published in the year 1794. It related to the explanation of the power which is possessed by the eye of adapting itself to different distances, which he attributed to the action of the external muscles of the eye, and not to the dilatation and contraction of the iris, nor to the muscularity of the crystalline lens, by which its convexity could be increased or diminished, a doctrine which had been promulgated in a paper by Dr. Thomas Young, in the preceding year. This subject is one of great interest, and has been very frequently agitated; and though an illustrious foreigner, M. Arago, has recently defended the theory of Dr. Young with great ingenuity and warmth, yet physiologists and anatomists are by no means agreed on the adoption of this or any other single explanation.

Mr. John Bell was Senior Wrangler at Cambridge in 1786, and a Fellow of Trinity College. Though labouring under physical disadvantages of no ordinary kind, and such as were apparently the most adverse to success in the public exercise of his profession as a lawyer, yet he conquered every difficulty and reached the highest eminence by his great acuteness and strength of mind, his extensive legal knowledge, and, not a little, likewise, by his sturdy integrity and love of truth, which he respected,—a rare virtue,—even in advocating

the claims of a client. Mr. Bell, with an uncommon exercise of philosophy, retired from the active duties of his profession, whilst in the receipt of a splendid income from it, on the first warnings of the approaches of the infirmities of old age. He was a man of great liberality and kindness of heart, and remarkable for the steadiness of his attachment to a large circle of professional and other friends.

The Rev. William Lax, formerly Fellow of Trinity College, and Lowndes's Professor of Astronomy and Geometry in the University of Cambridge, was Senior Wrangler in the year preceding Mr. Bell, and throughout life one of his most intimate friends: he contributed two papers to our Transactions; one in 1796, on a subject of no great importance, and the other in 1809, on the method of examining the divisions of astronomical instruments, in the same volume which contained papers on similar subjects by Mr. Cavendish and Mr. Troughton. The method proposed by Mr. Lax, though very ingenious, requires great labour and time, and is inferior in accuracy and efficiency to that which was adopted by Mr. Troughton for tabulating the errors of the primary divisions of circular instruments. Professor Lax was the author of Tables to be used with the Nautical Almanack, and he had built a small observatory at his residence in Hertfordshire, where he occupied himself for the last thirty years of his life with studies and pursuits connected with the advancement of astronomy.

Sir John Sinclair devoted nearly the whole of a very long and laborious life to pursuits and inquiries connected with the improvement of agriculture and the general benefit of his countrymen. He was a very voluminous author; and though different opinions may be entertained of the merit and usefulness of some of his later productions, the Statistical Account of Scotland which he originated, and arranged, will be a durable monument to his memory, presenting as it does a more complete and comprehensive record of the state of that kingdom at the period when it was compiled, than is to be found in the literature of any other country.

Dr. John Gillies, venerable alike for his great age and his amiable character, was the successor of Dr. Robertson, as the king's historiographer for Scotland: he was the author of a History of Greece and of the World from the conquests of Alexander to the age of Augustus, and he translated some of the Greek orators, the ethical, political and rhetorical treatises of Aristotle, upon whose speculative works generally he wrote a very enlarged commentary. He was a pleasing and popular writer, though not very profoundly acquainted with the great advances which have been made of late years in Germany and elsewhere in our knowledge of archæology and historical criticism.

Sir William Gell was well known as a topographical antiquary, and published works of great interest and research, some of them very splendidly embellished, on Pompeii, and on the modern, as illustrating the ancient topography of Troy, Ithaca, the Peloponnesus, Attica and Rome. He was a very accomplished artist and a man of great liveliness of conversation, and of very attractive man-

ners. Sir William Gell was formerly Fellow of Emanuel College, Cambridge, and was attached, for some time, in the quality of Vice-chamberlain, to the late Queen Caroline. He spent the later years of his life, a victim to the gout and other infirmities, at Naples, in the neighbourhood of those remarkable ruins which he had so carefully and so beautifully illustrated, and which continued to supply him, from day to day, with fresh objects of interesting inquiry.

Dr. Warren, though one of the most distinguished physicians in this metropolis, contributed very little, by his writings, to medical or general literature: he was considered to be an accomplished classical scholar, and a man of very extensive acquirements: he was a strenuous vindicator of the character and independence of his profession, and though his manners were somewhat abrupt, and sometimes apparently uncourteous, yet he was a man of very warm affections, and greatly beloved and respected by a large body of friends.

Those to whom Dr. William Elford Leach was known in his happier days, when in the full enjoyment of health and reason, can best appreciate the great loss which the natural sciences and our national museum sustained by that melancholy visitation, which, like the hand of death, terminated his scientific labours. His enthusiastic devotion to his favourite studies, his great knowledge of details, combined with no inconsiderable talents for classification, were eminently calculated to raise him to the very highest eminence as an original and philosophical naturalist. Though his career of research and discovery was prematurely cut short, yet we are chiefly indebted to him for the first introduction into this country of the natural system of arrangement in conchology and entomology, and for the adoption of those more general and philosophical views of those sciences which originated with Latreille and Cuvier. Dr. Leach was the author of a paper in our Transactions on the genus *Ocythoë*, to prove that it is a parasitical inhabitant of the Argonaut. He wrote several memoirs in the Linnæan Transactions; an excellent treatise on British Malacostraca: and he also contributed largely to the Zoological Miscellany, to Brewster's Encyclopædia and to the French *Dictionnaire des Sciences Naturelles*. He died of an attack of cholera on the 25th of August last, at the Palazzo St. Sebastiano, in the province of Tortona in Italy.

The last name which occurs in the melancholy list of our departed compatriot associates, is that of Dr. William Henry, to whom the science of chemistry generally, and of gaseous chemistry in particular, is under great obligations. He was the author of nine papers in our Transactions, many of them of great merit; and his System of Chemistry is one of the best written and best arranged compendiums of that important and extensive science, which has been published of late years, whether in our own language or in any other. The Memoirs of the Manchester Society are chiefly indebted to him, in conjunction with Dr. Dalton, for the high character which they have so long maintained. Dr. Henry, like Dr. Wollaston, made the results of science, obtained by the most original and diffi-

cult researches, the foundation of a splendid fortune, and few persons have contributed more effectually, by their discoveries and exertions to the promotion of those arts and manufactures which form the foundation of the prosperity of a great commercial nation.

The names of the Foreign members whom the Society has lost during the last year are, André Marie Ampère and Antoine-Laurent de Jussieu, both of them members of the Académie des Sciences de France.

Mons. Ampère was born at Lyons in 1775, and made his first appearance in the scientific world in a short work which showed considerable command of analysis, entitled *Considérations sur la Théorie Mathématique du Jeu*, in which the question of the safety of habitual and indefinite play, either against a single person of greater fortune, or indifferently against any number of persons, even when the game is perfectly fair and equal, is discussed and solved, and its result exhibited in a form full of warning to those by whom gaming is pursued as an occupation, in which success or failure is considered as the gift of fortune, and not the inevitable result of calculation. M. Ampère was subsequently appointed Professor of the Polytechnic School, and published memoirs on the integration of partial differential equations, and on other subjects, which show a profound knowledge of some of the most refined and difficult artifices of analysis: to him likewise we are indebted for memoirs on the Mathematical Theories of Electro-magnetic Currents, which are remarkable for the skill and ingenuity with which the powers of analysis are brought to bear on subjects apparently the most remote from their operation. His inquiry into the equation of Fresnel's wave surface is more remarkable as an example of resolute perseverance than of success, and his last work, on the Philosophy of the Sciences, showed him to be much less happy in his metaphysical, than in his physical and analytical speculations. M. Ampère was a man of great simplicity of character, and his extraordinary fits of absence of mind were not unfrequently made the subject of much innocent amusement. He took no part in the cabals and jealousies which too frequently disturb the peace of the world of science, and he was universally respected and beloved for his great integrity and the kindness of his affections.

Antoine-Laurent de Jussieu, a name singularly illustrious in the annals of botanical science, was born at Lyons in 1748. He was nephew to the great Bernard de Jussieu, under whose auspices he was first introduced into the scientific world of Paris, and appointed, at a very early age, demonstrator of botany in the Jardin du Roi. After this appointment, though originally destined for the profession of medicine, he devoted himself almost exclusively to the study of botany, more especially with a view to the establishment and development of the natural system of arrangement, a very bold and successful approximation to which had been effected by his uncle in the distribution of the plants in the Garden of the Trianon.* He

* This arrangement, made in 1759, is given by his nephew at the conclusion of

succeeded his uncle as administrator of the Jardin des Plantes in 1779, and published two memoirs of great originality and importance on the relative value of characters in the distinction of the genera and orders of plants. In the year 1789 he published his great and truly classical work entitled *Genera Plantarum secundum Ordines naturales disposita*, which caused a total revolution in the science of botany. To the modification and extension of the views contained in that work, rendered necessary by new observations and by the vast accession of new genera and orders, brought from the tropics, South America, Australia, and elsewhere, he devoted the remainder of his life. His later memoirs, many of which are of great value, are chiefly contained in the *Annales*, and subsequently in the *Mémoires du Muséum d'Histoire Naturelle*. M. de Jussieu was a man of very simple manners and amiable character, of a social and affectionate temper, and a perfect stranger to scientific jealousies and intrigues. He attained to an extreme old age, and had the happiness of witnessing the almost universal adoption of that system of botanical arrangement, the establishment of which had formed the great object of the labours of his life.

The Secretary then read the following Report of the Proceedings of the Council since the last Anniversary.

The Council, on the 3rd of March, adopted a Report, submitted to them by the Committee whom they had appointed for considering the communications from the Treasury and Excise Office, on the subject of the construction of instruments and tables for ascertaining the strength of spirits, in reference to the charge of duty thereon, and ordered it to be transmitted to the Lords Commissioners of His Majesty's Treasury; who, in acknowledging its receipt, were pleased to express "their best thanks to H. R. H. the President, and to the Society, for the obliging manner in which they had met the wishes of the Board, and to the Committee for the attention they gave to the subject, and for the valuable Report with which they had furnished that Board."

The Council, conformably with the recommendation of the Donation Fund Committee, have granted £50 from that fund to Professor Wheatstone, in aid of the experimental inquiry which he is prosecuting on the measure of the velocity of Electricity when passing along a conducting wire.

A letter from Baron Von Humboldt, addressed to H. R. H. the President, relating to a proposal for the cooperation of the Royal Society in carrying on an extensive series of magnetical observations, in various parts of the earth, having been communicated by H. R. H. to the Council, it was referred to the Astronomer Royal and to S. H. Christie, Esq., for their opinion thereupon. The Report of

his introduction to his great work, published in 1789: though extremely imperfect and in many respects erroneous, it was founded upon just principles, and was in almost every respect superior to those which had been proposed by Linnæus and by Tournefort.

these Gentlemen was ordered to be read to the Society and printed in its proceedings ; and a Committee has been appointed to consider of the best means of carrying into effect the measures recommended in that Report.

A paper, delivered to the Secretary at one of the ordinary meetings of the Society, entitled " Requisition for a Special General Meeting of the Royal Society," and signed by six of the Fellows, stating the purposes of such special meeting to be " to consider and determine the necessity of expunging from the Journal Book of the Society" certain minutes of its proceedings, and also " to consider the principle of a resolution, passed at an ordinary meeting of the Society, by which their thanks were withheld from the author of a work presented by him to the Society," having been laid before H. R. H. the President and Council, they were unanimously of opinion that no special meeting has the power of expunging minutes of past proceedings of the Society. The Council accordingly ordered a Special General Meeting of the Society to be called, for the purpose of taking into consideration only the latter of the two objects stated in the requisition.

Mr. Monk Mason having, in a letter addressed to H. R. H. the President, offered the Great Vauxhall Balloon for the use of the Society, a Committee was appointed to take this proposition into consideration and to report thereupon to the Council.

The Council have awarded a Copley Medal to Baron Berzelius for his application of the Doctrine of Definite Proportions in Determining the Constitution of Minerals. To the labours of this distinguished chemist, science is indebted for many of the facts by which the Laws of Definite Union were established. As early as 1807, soon after Dalton and Gay-Lussac had made known their views on this vital branch of modern chemistry, Berzelius commenced an elaborate examination on the proportions in which the elements of compound bodies are united, beginning with the salts, and subsequently extending his researches to all other departments of his science, as well to the products of organized existences as to those of the mineral world. The first part of the inquiry appeared in a series of essays in the *Afhandlingar i Fysik, Kemi, och Mineralogie*, t. iii. iv. v. and vi., as also in the *Memoirs of the Academy of Sciences of Stockholm*, for the year 1813. Since that period he has almost constantly been more or less occupied with researches bearing, or illustrative of, the same subject. His numerous analyses of minerals enabled him at once to elucidate their nature through the light derived from the laws of definite combination, and at the same time to supply in the composition of minerals a splendid confirmation of the universality of those laws. It is for this branch of his inquiry that the Copley Medal has been awarded.

A Copley Medal is also awarded to Francis Kiernan, Esq., for his discoveries relative to the Structure of the Liver, as detailed in his paper communicated to the Royal Society, and published in the *Philosophical Transactions* for 1833.

Before the researches of Mr. Kiernan, the liver was supposed to consist of two dissimilar substances, composed of brown parenchy-

matous granules, contained in a yellow substratum. The relation of the vessels and excretory ducts to these supposed dissimilar substances was not known; nor, although the organ was considered to be a conglomerate gland, were the glandules of which it was conjectured to be composed, defined in magnitude, shape, or disposition. Mr. Kiernan's discoveries show that in place of two textures there exists but one; and that the difference of colour results from the accidental congestion of one or other of the systems of vessels, which are found in the liver. Mr. Kiernan has further satisfactorily demonstrated the size and limits of the integral glandules of which the liver consists. He has traced the relation to these glandules of the different orders of vessels, which are distributed through the organ, and has explained the mechanism of biliary secretion. He has shown that all the blood employed in secreting bile is venous; and that the origins of the biliary ducts differ in an important respect from the origins of the ducts of all other glands: inasmuch as they form a series, not of coiled or branching tubes, but of anastomosing vessels, constituting a tubular network.

Mr. Kiernan's researches display great industry and ingenuity; when foiled by the difficulties which had foiled preceding anatomists, he applied a principle that had not been thought of before to facilitate the investigation of structure. Hitherto, however eminent the English have been in physiology, (and the most eminent of physiologists, Harvey, was an Englishman,) they have been behind the Germans and the Italians in anatomy. The discovery which Mr. Kiernan has made, exceeds in originality, and in importance is scarcely inferior to any single anatomical discovery on record. Its originality consists in this; it may be estimated from the circumstance that nothing which had been previously done on this subject affords a clue to what *he* has found; and the difficulty of the inquiry may be understood from this; that although many had undertaken it, all had previously failed. The importance of the facts displayed may be gathered from the consideration, that they greatly elucidate the morbid anatomy of the liver,—a part of the human frame, which is remarkable for the frequency and variety of its diseases, and at the same time for the facility with which it may be influenced by remedial agents.

The Royal Medal for the present year, which the Council had proposed to give to the most important paper in Astronomy communicated to the Royal Society within the last three years, is awarded to Sir John Frederick William Herschel, for his Catalogue of Nebulæ and Clusters of Stars, published in the Philosophical Transactions for 1833.

In delivering this Medal His Royal Highness addressed the Society as follows:—

This, Gentlemen, is the second time that a Royal Medal has been adjudged to Sir John Herschel, for researches in a department of Astronomy which has descended to him as an hereditary possession;

and I believe I may venture to say, that in no case has a noble inheritance been more carefully cultivated or more enriched by new acquisitions. The catalogue for which the Royal Medal is now given, contains a list of 2500 nebulae and clusters of stars, the same number which had been observed and catalogued by his father, though only 2000 of them are common to both catalogues; the right ascensions and declinations of all these objects are determined; the general character of their appearance recorded; and all those which present any very extraordinary character, shape, or constitution, of which there are nearly 100, are drawn with a delicacy and precision which is worthy of an accomplished artist. It presents a record of those objects so interesting as forming the basis of our speculations on the physical constitution of the heavens which are observable in this hemisphere, which is sufficiently perfect to become a standard of reference for all future observers, and which will furnish the means of ascertaining the changes, whether periodical or not, which many of them are probably destined to undergo. I trust, Gentlemen, that a long time will not elapse before we shall be enabled to welcome the return of Sir John Herschel to this country, with materials for a catalogue of the nebulae of the southern hemisphere as perfect and as comprehensive as that which we are this day called upon to signalize with the highest mark of approbation which it is in our power to bestow. He will then have fixed the monuments of an imperishable fame in every region of the heavens.

The Royal Medal for the present year, which the Council had proposed to give to the most important paper in Animal Physiology communicated to the Royal Society within the last three years, is awarded to George Newport, Esq., for his series of investigations on the Anatomy and Physiology of Insects, contained in his two papers published in the Philosophical Transactions within that period.

Mr. Newport, to whom the Society was indebted in 1832 for a very valuable and elaborate anatomical investigation of the nervous system of the *Sphinx ligustri* of Linnæus, and of the successive changes which that insect undergoes during the state of larva, and the earlier stages of the pupa state, published in the Philosophical Transactions of that year, has since prosecuted this arduous and laborious train of inquiry, under circumstances of peculiar difficulty, with extraordinary zeal and indefatigable perseverance. Within the period of the last three years he has enriched the Transactions with two papers, in the first of which, read to the Society in June 1834, he has extended his researches into the structure and arrangement of the different portions of the nervous system of the same insect, following their successive changes through the remaining stages of development to the completion of the imago, or perfect state. He devotes particular attention to the study of the periods at which those several changes occur; for he has found that they vary considerably in the rapidity of their progress at different epochs, according as the vital powers are called into action by external influences, or as they become exhausted by their efforts in effecting the growth, or

modifying the form of different systems of organs. The labours of Mr. Newport have determined, with great exactness, those periods, which had not before been ascertained.

Among the numerous original observations of Mr. Newport on the arrangement and connexions of the several parts of the nervous system, the description he gives of the origin and distribution of the visceral nerve, which he shows to be analogous to the pneumogastric nerve of vertebrated animals, and also of the system of nerves corresponding to those which have been considered as peculiarly subservient to the supply of the respiratory organs, are particularly deserving of notice. In the course of this investigation many new and important facts are brought to light, which had escaped the observation of Lyonet, Müller, Brandt and Straus-Durkheim. Mr. Newport has also traced a remarkable analogy in the origin and distribution of the two distinct classes of nerves, the one subservient to sensation, and the other to volition, belonging to insects, with those belonging to vertebrated animals, and has thus given greater extension to our views of the uniformity existing in the plans of animal organization than we before possessed, and which are thus made to comprehend the more minute, as well as the larger tribes of the animal creation.

In a memoir on the Respiration of Insects, more recently communicated to the Society, and of which, at its last meeting in June, the title only could be announced, Mr. Newport has, with great diligence and success, investigated the variations occurring in this function in the different periods of insect developement. He has minutely traced the several changes which the tracheæ and spiracles undergo during the transformations of the insect, and has particularly described the successive developement of the air-vesicles in connexion with the power of flight. He has given a minute and accurate description of the system of muscles, both of inspiration and of expiration, of the *Sphinx ligustri*; has investigated their various modes of action, with reference more especially to the different classes of nerves appropriated to these functions; and has established a distinction in the offices of these nerves, corresponding to the sources from which they derive their origin, and presenting remarkable analogies with similar distinctions in the nerves of vertebrated animals. He has given the result of a series of original experiments on the products of respiration in this class of animals, and of their variations under different circumstances of temperature, of submersion, and of confinement in unrespirable and deleterious gases; and he has deduced important conclusions relative to the circumstances which govern the properties of oxygen consumed and of carbonic acid generated. He has also communicated various results to which he has arrived concerning the capabilities which insects possess of supporting life during longer or shorter periods, when immersed in different media.

For the original views presented in these two papers, as well as for the mass of valuable information they contain, the results of much laborious and well-directed research in the more difficult departments of the Anatomy and Physiology of Insects, prosecuted

under circumstances which would have repressed the exertions of a less ardent inquirer into truth, the Council have considered Mr. Newport as highly deserving the distinction they have conferred upon him by the award of the Royal Medal for Animal Physiology in the present year.

The Council propose to give one of the Royal Medals in the year 1839 to the most important unpublished paper in Astronomy communicated to the Royal Society for insertion in their Transactions after the present date, and prior to the termination of the Sessions in June 1839.

The Council propose to give one of the Royal Medals in the year 1839, to the most important unpublished paper in Physiology, communicated for insertion in their Transactions after the present date, and prior to the termination of the Sessions in June 1839.

The Statutes relating to the election of Council and Officers were then read by the Secretary; and Davies Gilbert, Esq., and Francis Kiernan, Esq., being nominated by the President, with the approbation of the Meeting, Scrutators to assist the Secretaries in examining the Balloting Lists, the Votes of the Fellows present were collected.

The Ballot being taken, the Scrutators reported the following as the result:

President: His Royal Highness the Duke of Sussex, K.G.—*Treasurer:* Francis Baily, Esq.—*Secretaries:* Peter Mark Roget, M.D.; John George Children, Esq.—*Foreign Secretary:* Charles Konig, Esq.

Other Members of the Council: George Biddell Airy, Esq., A.R.; William Allen, Esq.; John Bostock, M.D.; The Earl of Burlington; Samuel Hunter Christie, Esq.; Viscount Cole, M.P.; Joseph Henry Green, Esq.; George Bellas Greenough, Esq.; William Lawrence, Esq.; John Lindley, Phil. D.; John William Lubbock, Esq., M.A.; Rev. George Peacock, M.A.; William Hasledine Pepys, Esq.; Rev. Adam Sedgwick, M.A.; William Henry Smyth, Capt. R.N.; William Henry Fox Talbot, Esq.

The Thanks of the Society were then voted to the Scrutators for their trouble in assisting at the election.

The following is the statement with respect to the Receipts and Payments of the Society during the preceding year, which was laid on the table by the Treasurer.

*Statement of the Receipts and Payments of the Society between Nov. 28, 1835,
and Nov. 29, 1836.*

1. RECEIPTS.

	£.	s.	d.
Balance in the hands of the Treasurer at the last Audit ..	218	3	8
40 Weekly Contributions, at one shilling	104	0	0
103 Quarterly Contributions, at £1	391	0	0
29 Admission Fees	290	0	0
2 Compositions for Annual Payments at £40.	80	0	0
7 Compositions for Annual Payments at £60.	420	0	0

Rents :—

	£.	s.	d.
One year's rent of estate at Mablethorpe: due at Michaelmas, (less the expenses of defending the suit, £13 17 6).....	93	2	6
One year's rent of lands at Acton: due at Michaelmas	60	0	0
One year's fee-farm rent of lands in Sussex; land-tax deducted: due at Michaelmas ..	19	4	0
One fifth of the clear rent of an estate at Lambeth Hill, from the Royal College of Physicians, in pursuance of Lady Sadleir's will: due at Midsummer.....	3	0	0
Interest to Christmas 1835 on the produce of the sale of the Coleman-street premises ..	42	13	8
	<hr/>	218	0 2

Dividends on Stock :—

One year's dividends on £14,000 Reduced 3 per cent. Annuities	420	0	0
Dividend on £3452. 1. 1 Consols, the produce of the premises in Coleman-street, sold ..	51	15	7

Donation Fund.

One year's dividends on £3820. 19. 3 Consols	114	12	6
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Pulteney Fund.

One year's dividends on £200 Consols	6	0	0
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Rumford Fund.

One year's dividends on £2161. 0. 10 Consols	64	16	8
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Fairchild Fund.

One year's dividends on £100 New South Sea Annuities	3	0	0
	<hr/>	660	4 9

Carried forward £2381 8 7

	£.	s.	d.
Brought forward.....	2381	8	7
From the Lords of the Treasury, being the amount of sundry items paid on account of the Excise Committee in the present and preceding years.....	135	17	0
Miscellaneous Receipts:—			
Sale of Philosophical Transactions and Abstracts of Papers	313	11	8
Sale of Sir H. Davy's Discourses.....	15	0	
	450	3	8
Total Receipts	£2831	12	3

2. PAYMENTS.

	£.	s.	d.
<i>Lady Sadleir's Legacy.</i> —The Poor of the Parish, in pursuance of Lady Sadleir's Will.....	3	0	0
<i>Fairchild Lecture.</i> —The Rev. J. J. Ellis, for delivering the Fairchild Lecture.....	3	0	0
<i>Bakerian Lecture.</i> —John William Lubbock, Esq., for the Bakerian Lecture.....	4	0	0
<i>Donation Fund.</i> —Mr. Wheatstone, for Experiments	50	0	0

Salaries:—	£.	s.	d.
Dr. Roget, one year, as Secretary	105	0	0
J. G. Children, Esq., one year, as Secretary..	105	0	0
Ditto for Index to Phil. Trans.	5	5	0
C. Konig, Esq., one year as Foreign Secretary	20	0	0
Mr. Robertson, one year, as Assistant-Secretary	160	0	0
Mr. W. E. Shuckard, one year as Librarian..	50	0	0
Mr. Gould, one year, as Porter	60	0	0
	505	5	0

Fire Insurance, on the Society's Property	22	11	6
Mrs. Coppard: Gratuity.....	10	0	0

Excise Committee (*repaid by the Lords of the Treasury*):

Printing Proceedings of Excise Committee	19	16	0
Mr. Russell, for calculating Tables.....	55	0	0
Mr. Jones, for calculating Tables	10	0	0
Mr. Newman	3	4	4
	88	0	4
Taylor: on account of printing the Catalogue	200	0	0
Carried forward	£885	16	10

		£.	s.	d.
Bills :—	Brought forward	885	16	10
Taylor :				
Printing the Phil. Trans., 1835, part 2, and				
1836, part 1; Proceedings, Nos. 22—25;				
Circulars, Lists of Fellows, Ballot-lists,				
Statement of Payments, and Minutes of				
Council, &c.	340	10	6	
Bowles and Gardiner :				
Paper for the Phil. Trans., 1836, parts 1				
and 2.....	207	4	0	
Basire :				
Engraving and Copper-plate Printing for				
the Phil. Trans., 1836, parts 1 and 2, &c.	343	9	3	
Walker :				
Engraving for Phil. Trans., 1836, part 2.	54	3	0	
Gyde :				
Sewing and Boarding 1650 Parts of Phil.				
Trans.	56	6	8	
				1001 13 5
Mr. Bassett: Surveying, (<i>last year</i>)	38	19	0	
Few & Co., Solicitors	41	9	7	
Tuckett :				
Bookbinding	37	6	8	
Chappell :				
Stationery	25	17	0	
Saunderson :				
Shipping expenses	9	10	3	
Brecknell and Turner :				
Wax Lights, Candles, and Lamp Oil	35	16	0	
Skelton :				
Cleaning Chandeliers; and repairing Lamps,				
Locks, &c.	7	6	2	
Cubitt :				
Repairing Window Frames, Map Cases, &c.	44	17	8	
Varnham :				
Map Cases	14	19	6	
Cobbett and Son :				
Window-cleaning and Glazing	1	15	0	
Gwillim :				
Large Mats, Brushes, Fire wood, &c.	5	3	8	
Exchequer Fee.....		6	6	
Arnold and Dent :				
Cleaning and Regulating Clocks	4	4	0	
Wood :				
For Coals	30	16	0	
Troughton and Simms :				
Repairing Instruments	7	8	6	
				305 15 6
	Carried forward.....	£2193	5	9

	£.	s.	d.
Brought forward.....	2193	5	9
Taxes and Parish Rates :			
Window Tax	11	1	9
Land Tax	3	15	0
Poor Rate	8	0	0
Church Rate	2	15	0
Rector's Rate.....	1	0	0
	<hr/>		
	26	11	9
Petty Charges :			
L'Institut Journal	15	0	
Postage and Carriage.....	17	2	2
Extra Porterage.....	1	4	0
Expenses on Foreign Packets, &c.	7	12	9
Stamps	1	5	6
Cleaning Library	19	6	
Charwoman's Wages	27	6	0
Extra Charwoman's work	3	10	6
Miscellaneous expenses	18	14	5
	<hr/>		
	78	9	10
<hr/>			
Total Payments	£2298	7	4
Balance in the hands of the Treasurer	533	4	11
	<hr/>		
	£2831	12	3
	<hr/>		

FRANCIS BAILY, *Treasurer.*

November 29th, 1836.

The Treasurer remarked, that all the sums due to the Society have been collected, except £35. 2s. 0d. owing by six defaulters. And all the claims on the Society have been paid, excepting three unsettled bills amounting to about £100.

The Treasurer also made the following statement with respect to the number of Fellows, viz :

	Patron and Honorary	Foreign.	Having compound- ed.	Paying 2l. 12s. Annually.	Paying 4l. 0s. Annually.	Total.
November, 1835	10	48	598	41	96	793
Since elected .....	.....	.....	+9	.....	+21	
Since deceased .....	.....	-2	-17	-4	-2	
Since compounded .....	.....	.....	+1	.....	-1	
Defaulters .....	.....	.....	.....	.....	-5	
November, 1836	10	46	591	37	109	793

The Treasurer farther remarked, that, agreeably to the practice of preceding Treasurers, the several *trust* accounts are blended with

the statement of the property belonging to the Society. But it may be the subject of consideration whether such accounts ought not, in future, to be kept totally distinct and separate. At the last anniversary there was a balance of £356. 5s. 10*d.* arising from the sale of MSS. to the British Museum, which, together with the balances on the Rumford and Donation funds, were then (and are now) included in the general assets of the Society; but which must be specially appropriated to particular purposes, and not to the general expenditure of the Society.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1836.

No. 28.

December 8, 1836.

FRANCIS BAILY, Esq., V.P. and Treas., in the Chair.

Charles Mackenzie, Esq., who at the last Anniversary had ceased to be a Fellow from the non-payment of his annual contribution, was, at this meeting, re-admitted by ballot into the Society, agreeably to the provision of the Statutes.

A paper was read, entitled, "Inquiries respecting the Constitution of Salts. Of Oxalates, Nitrates, Phosphates, Sulphates, and Chlorides." By Thomas Graham, Esq., F.R.S. Edin., Professor of Chemistry in the Andersonian University of Glasgow, Corresponding Member of the Royal Academy of Sciences of Berlin, &c. Communicated by Richard Phillips, Esq., F.R.S.

The results which the author had obtained from his former experiments, and of which he communicated an account to the Royal Society, suggested to him the probability that the law with respect to water being a constituent of sulphates, would extend also to any hydrated acid and the magnesian salt of that acid. As he had already found that the sulphate of water is constituted like the sulphate of magnesia, so he now finds the oxalate of water to resemble the oxalate of magnesia, and the nitrate of water to resemble the nitrate of magnesia. His researches render it probable that the correspondence between water and the magnesian class of oxides extends beyond their character as bases; and that in certain subsalts of the magnesian class of oxides, the metallic oxide replaces the water of crystallization of the neutral salt, and discharges a function which was thought peculiar to water. In the formation of a double sulphate, the author finds that a certain degree of substitution or displacement occurs; such as the displacement of an atom of water pertaining to the sulphate of magnesia, by an atom of sulphate of potash, to form the double sulphate of magnesia and potash. The same kind of displacement appears to occur, likewise, in the construction of double oxalates; and the application of this principle enables us to understand the constitution both of the double and super-oxalates, and to explain the mode of their derivation.

The author then proceeds to apply these principles to the analysis of the oxalates; and 1st, of the oxalate of water, or hydrated oxalic acid; 2ndly, of oxalate of zinc; 3rdly, of oxalate of magnesia; 4thly, of oxalate of lime; 5thly, of oxalate of barytes; 6thly, of oxalate of potash; 7thly, of binoxalate of potash; 8thly, of quadroxalate of potash; 9thly, of oxalate of ammonia; 10thly, of oxalate of soda; 11thly, of binoxalate of soda; and lastly, of the double oxalates, such as, 1st, oxalate of potash and copper; 2ndly, oxalate of chromium and potash; 3rdly, oxalate of peroxide of iron and potash; and 4thly, of oxalate of peroxide of iron and soda.

In the second section he treats of the nitrates; and 1st, of hydrated nitric acid, or the nitrate of water; 2ndly, of nitrate of copper; 3rdly, of subnitrate of copper; 4thly, of nitrate and subnitrate of bismuth; 5thly, of nitrate of zinc; 6thly, of nitrate of magnesia; and 7thly, of supposed double nitrates and supernitrates. He concludes, from his experiments on this subject, that there is no proof of the existence of a single supernitrate.

In the third section he discusses the constitution of the phosphates. Phosphoric acid, he observes, is quite peculiar in being capable of combining with bases in three different proportions; forming, besides the usual class of monobasic salts, containing one atom of acid to one atom of protoxide as base, two other anomalous classes of salts, in which two or three atoms of base are united to one atom of acid, namely, the pyrophosphates and the common phosphates, as they are usually denominated, but which the author proposes to designate by the terms, *bibasic*, and *tribasic* phosphates. Arsenic acid forms only one class of salts; but that class is anomalous; every member of it containing three atoms of base to one atom of acid, like the common, or tribasic, phosphates. These anomalous classes of phosphates and arseniates, with, perhaps, the phosphites, are, the author believes, the only known salts to which the ordinary idea of a subsalt is truly applicable: all other reputed subsalts being probably neutral in composition, as has been shown by the author in the case of the subnitrate of copper; for they all bear an analogy to this salt in their small solubility and other properties, while they exhibit little resemblance to those classes of phosphates and arseniates which really possess more than one atom of base. A table is then given, containing the formulæ expressing the composition of the most important phosphates, together with a new nomenclature by which, in accordance with his views, the author proposes to designate these salts. He then enters into the details of experiments illustrating the composition of, 1st, tribasic phosphate of soda, ammonia, and water, (or the microcosmic salt of the old chemists); 2ndly, tribasic phosphate of zinc and water, (or what is commonly called phosphate of zinc); 3rdly, tribasic arseniate of magnesia and water, (the common arseniate of magnesia); 4thly, tribasic phosphate of magnesia and water, (or ordinary phosphate of magnesia); and 5thly, tribasic phosphate of magnesia and ammonia, (or ammoniacomagnesian phosphate).

In the fourth section he treats of sulphates, and supports, by fur-

ther evidence, the opinion he formerly advanced; that as bisulphate of potash is a double sulphate of water and potash, and therefore neutral in its composition, so, with the sole exception of the anomalous class already noticed, all salts, usually considered as bisalts are, in like manner, really neutral in composition. He shows that this theory is strictly applicable to the red chromate of potash, which appeared to present a difficulty.

The chlorides are next considered. The law followed by the chlorides of the magnesian class of metals appears to be that they have two atoms of water strongly attached to them, and which may, therefore, be regarded as constitutional. Thus, chloride of copper crystallizes with two atoms of water, and with no lower proportion; but several chlorides of this class have two or four atoms more; the proportion of water advancing by multiples of two atoms. The chlorides have probably their analogues in the cyanides, although we are less acquainted with the single cyanides of iron, copper, &c.: but the disposition of the protocyanide of iron, and of the cyanide of copper to combine with two atoms of cyanide of potassium, may depend on the cyanides of iron and of copper possessing, like the corresponding chlorides, two atoms of constitutional water, which are displaced by two atoms of the alkaline cyanide in the formation of the double cyanides.

December 15, 1836.

WILLIAM LAWRENCE, Esq., V.P., in the Chair.

Thomas Graham, Esq., M.A., was elected a Fellow of the Society.

A paper was read, entitled, "Further Observations on the Optical Phenomena of Crystals." By Henry Fox Talbot, Esq., F.R.S.

The author had described, in a former paper, the remarkable circular mode of crystallization frequently occurring from a solution of borax in phosphoric acid, and producing, when examined by the polarising microscope, the appearance of a black cross, with four sectors of light, and occasionally coloured rings, upon each crystal. In the present memoir, he describes some deviations from the usual forms of crystalline circles; the most striking varieties consisting in the cross being itself highly coloured, instead of black, upon a white ground. The author shows that these crystals consist of boric acid alone, resulting from the decomposition of the borax by the phosphoric acid. He gives an explanation of the optical appearances they present on the hypothesis of their being constituted by an aggregate of acicular crystals, radiating from a central point; and the whole circle being of variable thickness at different distances from its centre, and acting with great energy on polarised light. Other modes of crystalline formation, dependent chiefly on the pre-

sence or absence of combined water, are next described. These sometimes produce crystals composed of two opposite sectors of a circle, united at the centre ; at other times, they exhibit irregular elongated shapes, having a stem, either subdivided at both extremities into minute diverging fibres, or abruptly truncated ; and occasionally they present regular geometric forms : but, whatever be their shape, they undergo, in general, spontaneous changes in the course of one or two days after they have been formed.

The author then notices a property belonging to some crystals, similar to that possessed by the tourmaline, of analysing polarized light ; for which reason he denominates them *analytic crystals*. As an example, he mentions those obtained by dissolving sulphate of chromium and potash in tartaric acid by the aid of heat. A drop of this solution, placed on a plate of glass, soon yields, by evaporation, filmy crystals, which frequently have this property. The plumose crystals of boracic acid, when crystallized from a solution of borax in phosphoric acid, also possess this analytic power, and present very beautiful appearances when viewed with the polarizing microscope. Another instance occurs in the oxalate of potash and chromium, a salt whose optical properties have been investigated by Sir David Brewster. If gum arabic be added to a solution of this salt, and a drop of it be put between two plates of glass, a very beautiful arborescent, but microscopic crystallization takes place, composing a multitude of minute prisms, growing, as if by a species of vegetation, and variously arranged in sprigs and branchlets, often resembling in miniature, the tufts of marine conservæ. A similar plumose appearance, accompanied with the same analytic properties, is obtained from the evaporation of a drop of a mixed solution of nitre and gum arabic. This analytic effect is shown to be the consequence of the high degree of doubly refractive power possessed by these crystalline filaments, and which exists even in those whose diameter is evanescent on microscopic examination. The author entertains hopes that it will be possible to obtain large and permanent artificial crystals, which may possess the advantages of the tourmaline, without the inconvenience resulting from its dark colour.

December 22, 1836.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

William Page Wood, Esq., was elected a Fellow of the Society.

“First Memoir on the Theory of Analytical Operations.” By the Rev. Robert Murphy, M.A., F.R.S., Fellow of Caius College, Cambridge.

The author considers the elements of which every distinct analytical process is composed, as of three kinds ; the first, being the *sub-*

ject, that is, the symbol on which a certain notified operation is to be performed; the second, the *operation* itself, represented by its own symbol; and the third, the *result*, which may be connected with the former two by the algebraic symbol of equality. The operations are either *monomial* or *polynomial*; *simple* or *compound*; and with respect to their order, are either *fixed* or *free*. He uses the term *linear* operations to denote those of which the action on any subject is made up by the several actions on the parts, connected by the signs *plus* or *minus*, of which the subject is composed; and these linear operations likewise may be monomial or polynomial.

A variety of theorems for the developement of functions of a very general nature are then deduced from expansions of the fundamental expressions, derived from the principles stated in the beginning of this memoir: and various laws embracing the relations subsisting between analytical operations, and the fundamental formulæ for their transformation are investigated.

“Observations and Experiments on the Solar Rays that occasion Heat; with the application of a remarkable property of these rays to the construction of the Solar and Oxy-hydrogen Gas Microscopes.” By the Rev. J. B. Reade. Communicated by J. G. Children, Esq., Sec. R. S.

The method employed by the author for obtaining, by a combination of lenses, the convergence to foci of the colorific solar rays, together with the dispersion of the calorific rays, consists in making a beam of solar light, which contains both kinds of rays, pass, after it has been converged to a focus by a convex condensing lens, through a second convex lens, placed at a certain distance beyond that focus: that distance being so adjusted as that the calorific rays, which, from their smaller refrangibility, are collected into a focus more remote from the first lens than the colorific rays, and consequently nearer to the second lens, shall, on emerging from the latter, be either parallel or divergent; while the colorific rays, which, being more refrangible, had been collected into a focus nearer to the first lens, and more distant from the second, will be rendered convergent by this second lens; so that the second focus, into which they are thus collected, will exhibit a brilliant light without manifesting any sensible degree of heat. The light so obtained may be advantageously applied to the solar, and to the oxy-hydrogen microscopes, from its producing no injurious effects on objects inclosed in Canada balsam, or even on living animalcules exposed to its influence.

Another improvement in the construction of the microscope employed by the author, consists in the cell for holding objects being made to move quite independently of the field glass; so that the best focus is obtained by an adjustment which does not disturb the field of view.

The Society then adjourned over the Christmas vacation, to meet again on the 12th of January next.

January 12, 1837.

CAPTAIN SMYTH, R.N., Vice-President, in the Chair.

"An attempt to account for the discrepancy between the actual Velocity of Sound in Air or Vapour, and that resulting from theory." By the Rev. William Ritchie, LL.D., F.R.S. Professor of Natural Philosophy at the Royal Institution, and in University College, London.

Sir Isaac Newton determined from theory that the velocity of the undulations of an elastic medium generally is equal to that which a heavy body acquires in falling by the action of gravity through half the height of a homogeneous atmosphere of that medium; but the actual velocity of sound in atmospheric air is found to be one eighth greater than what is assigned by that formula. This difference was attempted to be accounted for by Newton on the supposition that the molecules of air are solid spheres, and that sound is transmitted through them *instantly*. Laplace endeavoured to reconcile the difference between theory and observation, by the hypothesis that heat is disengaged from each successive portion of air during the progress of the condensed wave. The author of the present paper regards the hypothesis of Laplace as a gratuitous and improbable assumption; the falsehood of which he thinks is apparent from the fact that a rarefied wave advances through air with the same velocity as a condensed wave, which would not be the case if in either instance their progress were influenced by the heat evolved. He then enters into calculations to show that if the molecules of water be assumed as incompressible, and, when at the temperature of maximum density, very nearly in absolute contact, we ought, in estimating the velocity of sound in steam, to add to the velocity given by the formula of Newton, the rectilinear space occupied by the molecules; which, if a cubic inch of water be converted into a cubic foot of steam, will be one twelfth of the distance. By comparative experiments with a tuning-fork held over a tube, closed at one end, and containing at one time air, and at another steam, and also by similar trials with organ pipes of variable lengths, the author found a close agreement between his theory and observation. He also shows that this theory furnishes the means of determining, *à priori*, the density of a liquid, if the velocity of sound in the vapour of that liquid be given. In a postscript he adduces further confirmation of the truth of his theory by observations on the velocity of sound in hydrogen gas, and in carbonic acid gas.

January 19, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

Benjamin Bond Cabbell, Esq., Charles Holland, M.D., John Urpath Rastrick, Esq., and Samuel Solly, Esq., were elected Fellows.

“Researches towards establishing a Theory of the Dispersion of Light.” By the Rev. Baden Powell, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford.

The author here prosecutes the inquiry on the dispersion of light which was the subject of his former papers published in the Philosophical Transactions for 1835 and 1836, extending it to media of higher dispersive powers, which afford a severer test of the accuracy of M. Cauchy's theory. He explains his methods of calculation and the formulæ on which his computations are founded, and which are different from those employed in his former investigations: and then states the results in a tabular form. On the whole he concludes that the formula, as already deduced from the undulatory theory, applies sufficiently well to the case of media whose dispersion is as high as that of oil of anise-seed: or below it, such as nitric, muriatic, and sulphuric acids, and the essential oils of angelica, cinnamon, and sassafras, balsam of Peru, and kreosote. It also represents, with a certain general approximation to the truth, the indices of some more highly dispersive bodies. The author therefore considers it as extremely probable that the essential principle of the theory has some real foundation in nature. From the regularity which he finds in the deviation of observation from theory, he thinks it likely that the formula only requires to receive some further development, or extension, in order to make it apply accurately to the higher cases, while it shall still include the simpler form which so well accords with the lower.

“A few remarks on the Helm Wind.” By the Rev. William Walton, of Allenheads, near Hexham. Communicated by P. M. Roget, M.D., Sec. R.S.

On the western declivity of a range of mountains, extending from Brampton, in Cumberland, to Brough, in Westmoreland, a distance of 40 miles, a remarkably violent wind occasionally prevails, blowing with tremendous violence down the western slope of the mountain, extending two or three miles over the plain at the base, often overturning horses with carriages, and producing much damage, especially during the period when ripe corn is standing. It is accompanied by a loud noise, like the roaring of distant thunder: and is carefully avoided by travellers in that district, as being fraught with considerable danger. It is termed the *helm wind*; and its presence is indicated by a belt of clouds, denominated the *helm bar*, which rests in front of the mountain, three or four miles west of its summit, and apparently at an equal elevation, remaining immovable during twenty-four or even thirty-six hours, and collecting or attracting to itself all the light clouds which approach it. As long as this bar continues unbroken, the wind blows with unceasing fury, not in gusts, like other storms, but with continued pressure. This wind extends only as far as the spot where the bar is vertical, or immediately over head; while at the distance of a mile farther west, as well as to the east of the summit of the mountain, it is not unfrequently almost a perfect calm. The author details the particulars.

of an expedition which he made with a view to investigate the circumstances of this remarkable meteorological phenomenon, and proposes a theory for its explanation.

"A Meteorological Journal kept at Allenheads, 1400 feet above the level of the Sea, from the 1st of May to the 1st of November, 1836." By the Rev. William Walton. Communicated by P. M. Roget, M.D., Sec. R.S.

January 26, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

A paper was read, "On the Structure of the Brain in Marsupial Animals." By Richard Owen, Esq., F.R.S., Hunterian Professor of Anatomy to the Royal College of Surgeons.

The author describes a remarkable modification in the commissural apparatus, apparently provided with a view to establish communications between the cerebral hemispheres, which he has observed in the brains of marsupial animals, and which has hitherto been regarded as constituting the essential difference between the brains of oviparous and mammiferous vertebrata, but which he considers as indicating a certain relation between the greater perfection of that organ, resulting from the superior magnitude of the great commissure, or corpus callosum, and the placental mode of development in the true mammalia. In a former paper he adduced evidence tending to show that both a small development of the cerebral organ, and an inferiority of intelligence are the circumstances in the habits and structure of this singular tribe of animals most constantly associated with the peculiarities of their generative economy: and the repeated dissections he has since made, an account of which is given in the present paper, have afforded him the most satisfactory confirmation of this coincidence, between a brief intra-uterine existence, together with the absence of a placental connexion between the mother and the fœtus, and an inferior degree of cerebral development. Thus, on comparing the structure of the brain in the Beaver and in the Wombat, he finds that the corpus callosum, or great commissure which unites the supraventricular masses of the hemispheres in the former, as well as in all other placentally developed mammalia, and which exists in addition to the fornix, or hippocampal commissure, is wholly absent in the latter animal: and that a similar deficiency exists in the brain of the Great and Bush Kangaroos, of the Vulpine Phalanger, of the Ursine and Mange's *Dasyurus*, and of the Virginian Opossum; whence he infers that it is probably the characteristic feature of the structure of the marsupial division of mammalia. In this modification of the commissural apparatus, the Marsupialia present a structure of brain which is intermediate between that of the Placental Mammalia and Birds; and hence the Marsupialia, together with the Monotremata, may be regarded as constituting a distinct and peculiar group in the former of these classes, although they include forms, which typify the different orders of the ordinary Mammalia.

February 2, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

"Observations on the Electro-chemical Influence of long-continued Electric Currents of Low Tension." By G. Golding Bird, Esq., F.L.S., F.G.S., Lecturer on Experimental Philosophy at Guy's Hospital. Communicated by Thomas Bell, Esq., F.R.S.

The author, after observing that the brilliant discoveries in electro-chemistry obtained by Sir Humphry Davy were effected by the employment of voltaic currents of high intensity, elicited by means of large batteries, adverts to the labours of M. Becquerel, to whom we are indebted for the knowledge of the chemical agency of feeble currents in reducing several refractory oxides to the metallic state: and also to those of Dr. E. Davy, Bucholtz, and Professor Faraday in effecting decompositions of other substances by similar means. In prosecuting this branch of inquiry, the author employed an apparatus analogous to that of Professor Daniell, for obtaining an equal and continuous current of low intensity from a single pair of plates: the metallic solution, in which a copper-plate was immersed, being contained in a glass tube, closed at the bottom by a diaphragm of plaster of Paris, and itself plunged in a weak solution of brine contained in a larger vessel, in which a plate of zinc was immersed; and a communication being established between the two metallic plates by connecting wires. By the feeble, but continuous current thus elicited, sulphate of copper is found to be slowly decomposed, affording beautiful crystals of metallic copper. Iron, tin, zinc, bismuth, antimony, lead, and silver may, in like manner, be reduced, by a similar and slightly modified process; in general appearing with metallic lustre, and in a crystalline form, and presenting a remarkable contrast in their appearance to the irregular, soft, and spongy masses obtained from the same solutions by means of large batteries. The crystals of copper rival in hardness and malleability the finest specimens of native copper, which they much resemble in appearance. The crystallization of bismuth, lead, and silver, by this process, is very beautiful; that of bismuth being lamellar, of a lustre approaching to that of iron, but with the reddish tint peculiar to the former metal. Silver may thus be procured of the whiteness of snow, and usually in the form of needles. Some metals, such as nickel, which, when acted on by currents from large batteries, are deposited from their solutions as oxides only, are obtained, by means of the apparatus used by the author, in a brilliant metallic form. He farther found that he could in this way reduce even the more refractory metallic oxides, such as silica, which resist the action of powerful batteries, and which M. Becquerel could only obtain in alloy with iron. By a slight modification of the apparatus he was enabled to form amalgams both of potassium and of sodium with mercury, by the decomposition of solutions of chlorides of those bases; and in like manner ammonium was easily reduced, when in contact with mercury, by the influence of a feeble voltaic current. In this last

experiment it was found that an interruption to the continuance of the current, even for a few seconds, is sufficient to destroy the whole of the product which had been the result of the previous long-continued action; the spongy ammoniacal amalgam being instantly decomposed, and the ammonia formed being dissolved in the surrounding fluid.

February 9, 1837.

FRANCIS BAILY, Esq., V. P. and Treasurer, in the Chair.

Edmund Halswell, Esq., who, at the last Anniversary, had ceased to be a Fellow, from the non-payment of his annual contribution, was, at this meeting, readmitted by ballot into the Society, agreeably to the provision of the statutes.

A paper was read, in part, entitled, "On the Elementary Structure of Muscular Fibre of Animal and Organic Life." By Frederick Skey, Esq., Assistant Surgeon to St. Bartholomew's Hospital. Communicated by John Bostock, M.D., F.R.S.

February 16, 1837.

The Right Honourable the EARL OF BURLINGTON, V.P., in the Chair.

The reading of a paper entitled, "On the Elementary Structure of Muscular Fibre of Animal and Organic Life." By Frederick Skey, Esq., Assistant Surgeon to St. Bartholomew's Hospital. Communicated by John Bostock, M.D., F.R.S., was resumed and concluded.

The author concludes, from his microscopic examinations of the structure of muscular fibres, that those subservient to the functions of animal life have, in man, an averagediameter of one 400dth of an inch, and are surrounded by transverse circular striæ varying in thickness, and in the number contained in a given space. He describes these striæ as constituted by actual elevations on the surface of the fibre, with intermediate depressions, considerably narrower than the diameter of a globule of the blood. Each of these muscular fibres, of which the diameter is one 400dth of an inch, is divisible into bands or fibrillæ, each of which is again subdivisible into about one hundred tubular filaments, arranged parallel to one another, in a longitudinal direction, around the axis of the tubular fibre which they compose, and which contains in its centre a soluble gluten. The partial separation of the fibrillæ gives rise to the appearance of broken or interrupted circular striæ, which are occasionally seen. The diameter of each filament is one 16,000dth of an inch, or about a third part of that of a globule of the blood. On the other hand, the muscles of organic life are composed, not of fibres similar to those above described, but of filaments only; these filaments being interwoven with each other in irregularly disposed lines of various thickness; having for the most part a longitudinal direction, but forming a kind of untraceable network. They are readily distinguishable from tendinous fibres, by the

filaments of the latter being uniform in their size, and pursuing individually one unvarying course, in lines parallel to each other. The fibres of the heart appear to possess a somewhat compound character of texture. The muscles of the pharynx exhibit the character of animal life; while those of the œsophagus, the stomach, the intestines, and the arterial system, possess that of inorganic life. The determination of the exact nature of the muscular fibres of the iris presented considerable difficulties, which the author has not yet been able satisfactorily to overcome.

A paper was also in part read, entitled, "On the Function of the Medulla Oblongata and Medulla Spinalis, and on the Excito-motory System of Nerves." By Marshall Hall, M.D., F.R.S. L. and E., &c.

February 23, 1837.

The Right Honourable the EARL OF BURLINGTON, V.P., in the Chair.

Richard Partridge, Esq., was elected a Fellow of the Society.

The reading of Dr. Marshall Hall's paper was resumed, but not concluded.

March 2, 1837.

WILLIAM LAWRENCE, Esq., V.P., in the Chair.

The reading of a paper, entitled, "On the Function of the Medulla Oblongata and Medulla Spinalis, and on the Excito-motory System of Nerves." By Marshall Hall, M.D., F.R.S., L. and E., &c., was resumed and concluded.

The author begins by observing that a former memoir of his, entitled, "On the Reflex Function of the Medulla Oblongata and Medulla Spinalis," published in the Philosophical Transactions for 1833, has been translated into German, and favourably spoken of by Professor Muller, of Berlin. He states that his object in the present paper is to unfold what he calls a great principle in physiology; namely, that of the special function, and the physiological and pathological action and reactions of the true spinal marrow, and of the excito-motory nerves. The two experiments which he regards as affording the type of those physiological phenomena and pathological conditions, which are the direct effects of causes acting in the spinal marrow, or in the course of the motor nerves, are the following:—1. If a muscular nerve be stimulated, either mechanically by the forceps, or by means of galvanism passed transversely across its fibres, the muscle or muscles to which it is distributed are excited to contract.—2. The same result is obtained when the spinal marrow itself is subjected to the agency of a mechanical or galvanic stimulus. The following experiment, on the other hand, presents the type of all the actions of the reflex func-

tion of the spinal marrow, and of the excito-motory system of nerves, and of an exclusive series of physiological and pathological phenomena :—If in a turtle, from which the head and sternum have been removed, we lay bare the sixth or seventh intercostal nerve, and stimulate it either by means of the forceps or galvanism, both the anterior and posterior fins, with the tail, are immediately moved with energy. Hence the author infers the existence : 1st, of a true spinal marrow, physiologically distinct from the chord of intra-spinal nerves ; 2ndly, of a system of excito-motory nerves, physiologically distinct from the sentient and voluntary nerves ; and, 3rdly, of currents of nervous influence, incident, upwards, downwards, and reflex with regard to the spinal marrow.

A review is then taken of the labours of preceding physiologists relative to the functions of the nervous system : in which the author criticises the reasonings of Whytt, Legallois, Mr. Mayo, Dr. Alison, and Professor Muller ; and illustrates his own peculiar views by several experiments and pathological observations, which appear to him to show that muscular movements may occur, under circumstances implying the cessation of sensation, volition, and every other function of the brain ; and that these phenomena are explicable only on the hypothesis that impressions made on a certain set of nerves, which he terms *excito-motory*, are conveyed to a particular portion of the spinal marrow belonging to that system, and are thence reflected, by means of certain motor nerves, upon certain sets of muscles, inducing certain actions. The same actions may also be the result of impressions made directly either on the spinal marrow or on the motor nerves. He accordingly considers that the whole nervous system may be divided into,—1st, the *cerebral*, or the sentient and voluntary ; 2ndly, the *true spinal*, or the excitor and motor ; and, 3rdly, the *ganglionic*, or the nutrient, the secretory, &c. The excito-motory system presides over ingestion and exclusion, retention and egestion, and over the orifices and sphincters of the animal frame : it is therefore the nervous system of respiration, deglutition, &c., and the source of tone in the whole muscular system. The true spinal system is the seat or nervous agent of the appetites and passions, but is also susceptible of modification by volition. This theory he proceeds to apply to the explanation of several phenomena relating to the motions of the eyelids, pharynx, cardia, larynx, muscles of inspiration, sphincter ani, expulsors of the fæces and semen, to the tone of the muscular system generally, and to actions resulting from the passions. Lastly, he considers its application to various diseased states of the same functions, as manifested in cynic spasm, vomiting, asthma, tenesmus, strangury, crowing inspiration, convulsions, epilepsy, tetanus, hydrophobia, and paralysis.

Reference is made, in the course of the paper, to several drawings and diagrams, which, however, have not yet been supplied.

March 9, 1837.

The Rev. ADAM SEDGWICK, M.A., V.P., in the Chair.

A paper was read, entitled, "Researches on the Tides. Seventh Series. On the Diurnal Inequality of the Height of the Tide, especially at Plymouth and at Sincapore : and on the Mean Level of the Sea." By the Rev. W. Whewell, A.M., F.R.S., Fellow of Trinity College, Cambridge.

The diurnal inequality which the author investigates in the present paper, is that by which the height of the morning tide differs from that of the evening of the same day ; a difference which is often very considerable, and of great importance in practical navigation, naval officers having frequently found that the preservation or destruction of a ship depended on a correct knowledge of the amount of this variation. In the first section of the paper he treats of the diurnal inequality in the height of the tides at Plymouth, at which port good tide observations are regularly made at the Dock Yard ; and these observations clearly indicate the existence of this inequality. As all the other inequalities of the tides have been found to follow the laws of the equilibrium theory, the author has endeavoured to trace the laws of the diurnal inequality by assuming a similar kind of correspondence with the same theory ; and the results have confirmed, in the most striking manner, the correctness of that assumption. By taking the moon's declination four days anterior to the day of observation, the results of computation accorded, with great accuracy, with the observed heights of the tides : that is, the period employed was the fifth lunar transit preceding each tide.

In the second section, the observations made on the tides at Sincapore from August 1834 to August 1835, are discussed. A diurnal inequality was found to exist at that place, nearly agreeing in law and in amount with that at Plymouth ; the only difference being that, instead of four days, it was found necessary to take the lunar declination a day and a half preceding the tide ; or, more exactly, at the interpolated, or north lunar transit, which intervened between the second and third south transit preceding the tide. The diurnal inequality at Sincapore is of enormous magnitude, amounting in many cases to six feet of difference between the morning and evening tides ; the whole rise of the mean tide being only seven feet at spring tides, and the difference between mean spring and neap tides not exceeding two feet.

In the third section, the author considers the diurnal inequalities at some other places, and the general law of its progress. The change which the *epoch*, (that is, the anterior period at which the moon's declination corresponds to the amount and direction of the inequality,) in particular, undergoes, is a subject of great interest. At Liverpool, the epoch is found to be about six days and a quarter ; at Bristol, it is nearly six days ; and at Leith, it is as much as twelve days. On the east coast of America, it appears to be *zero*. On the coasts of

Spain, Portugal, and France, it is successively two, and three days ; and on those of Cornwall and Devonshire, four days ; thus observing a tolerably regular augmentation as it is traced along the line of coast from the shores of the Atlantic to the Firth of Forth, but travelling more slowly than the other inequalities.

In section fourth, the author treats of certain extreme cases of diurnal inequality ; particularly those which produce the phenomenon of a single tide in the twenty-four hours : such as that noticed by Capt. Fitzroy at King George's Sound, on the south coast of New Holland ; and that of Tonquin, referred by Newton to the interference of two tides arriving by different channels, but probably owing to the operation of the same law as that which gives rise to the diurnal inequality.

In section fifth, the author considers the subject of the mean height of the sea ; that is, the height midway between low water and high water each day : and arrives at the result that it is very nearly constant.

March 16, 1837.

The Right Honourable the EARL OF BURLINGTON, V.P.,
in the Chair.

John Burnet, Esq., was elected a Fellow of the Society ; and Charles Julius Roberts, M.D., was balloted for, but not elected.

A paper was read, entitled, " On the Tides." By John William Lubbock, Esq., F.R.S., &c. &c.

Since the author presented his last paper on the tides to the Society, his attention has been directed to ascertain the three following points : namely, 1st, Whether, from the discussion of the Liverpool observations with reference to a previous transit, these observations present the same kind of agreement with Bernouilli's theory as those of London : 2ndly, Whether, by taking into account a greater number of observations, the results given in his last paper remain sensibly unaltered : and 3rdly, Whether the *establishment* of the Port of London varies sensibly in different years ; and whether the removal of the old London bridge has occasioned any difference. In order to elucidate these points, he procured the assistance of Mr. Jones and Mr. Russell to compute numerous tables ; employing for that purpose a further sum of money placed at his disposal with this view by the British Association for the Advancement of Science. The results contained in the tables here presented, are all laid down in diagrams, on the same plan as those contained in his last paper, by which means they are much more readily understood. The author finds that the semi-menstrual correction for the interval at Liverpool presents the same agreement with observation as had been before noticed ; while the form or law of the semi-menstrual correction for the height is also the same as that indicated by the observations ; but in order to render the agreement complete it would be necessary to change the epoch, or to make a slight movement of the theory-curve in the diagrams. This

remarkable difference also obtains in the London semi-menstrual correction for the height.

The calendar month inequality at Liverpool, considered as resulting implicitly from the corrections due to changes in the declinations of the luminaries, and in the sun's parallax, agrees generally with Bernouilli's theory, and with the results deduced from the London observations given in the author's last paper.

The author finds that the *Establishment* of the Port of London has been subject to changes even since the beginning of the present century, and he notices the difficulty of predicting the time of high water with accuracy unless these changes can be accounted for. He also cites a very ancient Tide Table, from which it would appear that formerly the time of high water at London was an hour later than it is at present.

The Society then adjourned over the Easter recess, to meet again on the 6th of April next.

PROCEEDINGS
OF
THE ROYAL SOCIETY.

1837.

No. 29.

April 6th, 1837.

FRANCIS BAILY, Esq., V. P. and Treasurer, in the Chair.

Robert Hunter, Esq.; John Forbes Royle, M.D.; and Lieut-J. R. Wellsted, were severally elected Fellows of the Society.

A paper was in part read, entitled, "Further Observations on Voltaic Combinations; in a letter addressed to Michael Faraday, Esq., D.C.L. F.R.S., Fullerian Professor of Chemistry in the Royal Institution, &c. &c." By John Frederick Daniell, Esq., F.R.S., Professor of Chemistry in King's College, London.

April 13, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

William Archibald Armstrong White, Esq., was elected a Fellow of the Society.

The reading of Professor Daniell's paper on Voltaic Combinations was resumed and concluded.

In the course of an inquiry on the effects of changes of temperature upon voltaic action, the author was led to observe some curious disturbances and divisions of the electric current produced by the battery, arising from secondary combinations; the results of which observations form the subject of the present paper. He found that the resistance to the passage of the current was diminished by dissolving the sulphate of copper which was in contact with the copper in the standard sulphuric acid, instead of water. The increased effect of the current, as measured by the voltameter, was farther augmented by the heat evolved during the mixture; and wishing to study the influence of temperature in modifying these effects, the author placed the cells of the battery in a tub, filled with hot water. On charging the cells with a solution of muriate of ammonia in the interior, and aqueous solution of sulphate of copper in the exterior compartment, he observed that a portion of the current is discharged by the water in which the apparatus was immersed; its passage being indicated by the disengagement of gas betwixt the adjacent cells; in which case, one of the zinc rods is thrown out of action, and the copper of that cell acts merely as an electrode to the antecedent zinc. A saturated solution of common salt was

next placed in contact with the zinc, while the exterior compartments of the cells were filled with a saturated aqueous solution of sulphate of copper ; but the effects were much diminished. It thus appeared that the substitution of solutions of the muriates for dilute sulphuric acid was in every way disadvantageous ; and it was moreover found that, when the circuit was broken, the copper became seriously injured by their action, and by the formation of a submuriate of that metal.

Finding that the membranous tubes were unable to resist the action of the acid under the influence of high temperatures, the author substituted for them tubes of porous earthenware, of the same texture as that of which wine-coolers are commonly made, closed at their lower ends, and of the same height as the copper cells. The bottoms of the latter were fitted with sockets, for the reception of the tubes, and for confining them in their proper places ; the perforated copper plates, or colanders, which held the solid sulphate of copper, passing over their upper ends. The tubes can be easily removed, and instantly replaced ; and the facility of emptying and refilling them renders the addition of siphon-tubes unnecessary, except in very particular circumstances. A circular steam-vessel of tin plate was then provided, around which the cells could be placed upon blocks of wood, and closed in with a cover, containing a socket, which could, at pleasure, be connected with the steam pipe of a boiler. Two other sockets were also conveniently placed, provided with cork stoppers, through which the electrodes of the battery could pass, when the proper connexions were made. By using this apparatus the author determined that the increase of effect consequent on an augmentation of temperature is but in a slight degree dependent on an increase of conducting power in the electrolyte, but arises principally from its increased energy of affinity, producing a greater electromotive force.

In heating the battery by the steamer, it frequently happened that, when the thermometer had nearly reached the boiling point, and the action of the battery was at its maximum, a sudden cessation of its action would take place ; and this suspension of power would continue for hours, provided the high temperature were maintained. On turning off the steam, and quickly cooling the apparatus, the action would return as suddenly as it had ceased, though, generally, not to the full amount. On closely examining the voltameter, on these occasions, it was found that the current was not wholly stopped ; but that there existed a small residual current. This residual current was observed to be often directed in a course opposite to that which had before prevailed ; and it was, in that case, the excess of a counter current, arising from a force which was acting in the contrary direction. The author found that variable currents might be produced, under ordinary circumstances, from the separate single cells of the battery when the whole series is connected by short wires. He proved by a series of experiments that the deoxidation of the oxide of copper by the hydrogen is not the exciting cause of the secondary currents ; but that when the course of the main cur-

rent of the battery is obstructed by causing it to pass through the long wire of a galvanometer, or through the electrolyte of a voltameter, the course of the secondary current from each separate cell is always normal, or in the same direction: when, on the other hand, the battery-current is allowed to flow with the least possible resistance, as by completing the main circuit by a short wire, the secondary current of the separate cells is in the opposite direction. Hence the resistance may be so adjusted as that the secondary current shall altogether disappear, or alternate between the two directions.

The remainder of the paper is occupied with the detail of experiments made with a view to ascertain the effects of different degrees of resistance to the voltaic currents under a great variety of circumstances.

April 20, 1837.

The Right Honourable the Earl of BURLINGTON, V.P. in the Chair.

Frederic C. Skey, Esq., was elected a Fellow of the Society.

A paper was read in part, entitled, "Observations taken on the Western Coast of North America." By the late Mr. Douglas; with a report on his paper; by Major Edward Sabine, R.A., F.R.S. Communicated by the Right Honourable Lord Glenelg, one of His Majesty's Principal Secretaries of State, F.R.S., &c.

April 27, 1837.

FRANCIS BAILY, Esq., V.P. and Treas., in the Chair.

M. Antoine César Becquerel, Professor C. G. Ehrenberg, Admiral A. J. Von Krusenstern, and the Chevalier C. F. Mirbel, were elected Foreign Members of the Society.

The reading of Mr. Douglas and Major Sabine's paper, was resumed and concluded.

In the report prefixed to this paper, Major Sabine states, that Mr. Douglas was originally a gardener, and was, in the year 1833, recommended by Sir William Jackson Hooker to the late Mr. Joseph Sabine, who was then Secretary to the Horticultural Society of London, as a fit person to be employed by the Society in selecting and bringing to England a collection of plants from the United States of America. Having accomplished this mission to the complete satisfaction of his employers, he was next engaged on an expedition having similar objects with the former, but embracing a much larger field; namely, the tract of country extending from California to the highest latitude he might find it practicable to attain on the western side of the Rocky Mountains. Anxious to render to geographical and physical science all the services in his power, and to avail himself for that purpose of every opportunity which his visiting these hitherto imperfectly explored regions might afford him, he now endeavoured by diligent application to supply the deficiencies of his previous education. During the three months

which preceded his departure from England, he studied with unremitting ardour and perseverance for no less than eighteen hours each day; and, conquering every difficulty, acquired a competent knowledge of the principles of science, learned the uses of various instruments, and made himself thoroughly master of the methods of taking observations both at sea and on land.

The narrative proceeds to notice the arrival of Mr. Douglas in America, the progress of his undertaking, the loss of his collections and most of his books and papers, by the upsetting and dashing to pieces of the canoe in which he attempted to pass the rapids, and, lastly, his death in 1833, at Owhyhee, in the Sandwich Islands, whither he had proceeded on his return to Europe.

The books which were preserved, and which have been received by Major Sabine, consist of several volumes of Lunar, Chronometrical, Magnetical, Meteorological and Geographical observations, together with a volume of field sketches. The geographical observations of latitude and longitude refer to two distinct tracts of country; first, the Columbia river, and its tributaries; and the district to the westward of them: and, secondly, California. Mr. Douglas very judiciously selected the junctions of rivers, and other well characterized natural points, as stations for geographical determination. The papers containing the details of his magnetical inquiries comprise records of observation of the dip, and of the intensity, at various stations both in North America and in the Sandwich Islands.

“Analysis of the Roots of Equations.” By the Rev. R. Murphy, M.A. Communicated by John William Lubbock, Esq., F.R.S.

The object of this memoir is to show how the constituent parts of the roots of algebraic equations may be determined by considering the conditions under which they vanish; and, conversely, to show the signification of each such constituent part.

The following are the propositions on which the author's investigations are founded.

1. In equations of degrees higher than the second, the same constituent part of the root is found in several places, governed by the same radical sign, but affected with the different corresponding roots of unity as multipliers.

2. The root of every equation, of which the coefficients are rational, contains a rational part; for the sum of the roots could not otherwise be rational. This rational part, as such, is insusceptible of change in the different roots of the same equation; consequently its value is the coefficient of the second term, with a changed sign, divided by the number of roots, or index of the first term.

3. The supposed evanescence of any of the other constituent parts, implies that a relation exists between the roots; and if such a relation be expressed by equating a function of the roots to zero, that constituent part will be the product of all such functions, and a numerical factor.

4. The joint evanescence of various constituent parts, implies the coexistence of various relations between the roots, and that an in-

terpretation may be given to each of the constituent parts, riveting the expression of the root in the memory, and converting the solution of a problem into a condensed enunciation of various theorems. The author exhibits the application of these principles to equations of various degrees, beginning with quadratic and cubic, and proceeding to those involving higher powers.

“On the first changes in the Ova of the Mammifera, in consequence of Impregnation; and of the mode of origin of the Chorion.” By Thomas Wharton Jones, Esq. Communicated by Richard Owen, Esq., F.R.S.

The author having, in a former paper, described the structure of the unimpregnated ovum of mammiferous animals, now proceeds to investigate the changes which the ovum undergoes in consequence of impregnation. In the rabbit, the first perceptible difference is the addition of a thick gelatinous matter surrounding the parts of which the ovum was composed in its original state, and apparently derived from the ovaries. In the progress of development the vitellary membrane gives way, as happens in the ova of the newt, and of many of the oviparous animals. The gelatinous envelope acquired in the ovary, and which is more especially circumscribed and defined after impregnation, constitutes the only covering of the vascular blastoderma, after the giving way of the vitellary membrane, and afterwards forms the chorion, which in rodent animals, at a further stage of development, presents itself under the form of a thin and transparent membrane, very similar to the vitellary membrane of a bird's egg, and situated immediately outside the non-vascular and reflected layer of the umbilical or erythroid vesicle. The author draws similar conclusions with regard to the developement of the human ovum.

The second part of the paper relates to the changes taking place in the vitellus, the inferences concerning which are deduced chiefly from observations of the developement of the ova of batrachian reptiles. The author concludes that the disappearance of the germinal vesicle is prior to impregnation. In the newt, the vesicle, at first imbedded in the substance of the yelk, gradually approaches the surface, until its situation is immediately underneath the vitellary membrane: its coat, having now become very soft, gives way, allowing the contained fluid to be effused on the surrounding surface of the yelk; and the small depression in which the vesicle was lodged now forms the cicatricula. The effused fluid gives a degree of consistence to the matter composing the surface of the yelk, and thus promotes the formation of the blastoderma. In the frog, the surface of the yelk becomes every day more and more broken up, and the resulting crystalline forms described by Prevost and Dumas become smaller and smaller, until the surface of the black blastoderma appears under a magnifying glass like shagreen. The blastoderma, consisting of an aggregation of clear globules, different from those of the rest of the yelk, is now fully formed, and has extended itself so as to close in the white spot. The change which takes place in the yelk of the bird's egg appears to be limited to the neighbourhood of the cicatricula.

May 4th, 1837..

FRANCIS BAILY, Esq., V.P. in the Chair.

"On the adaptation of different modes of illuminating Light-houses, as depending on their situations and the object contemplated in their erection." By William Henry Barlow, Esq., in a Letter addressed to Peter Barlow, Esq., F.R.S., and communicated by him.

The letter of Mr. W. H. Barlow, addressed to his father, in which the paper is contained, is dated Constantinople, March 14th, 1837, and states that the experiments which he made with the Drummond light, and other means of illuminating Light-houses, and of which he now communicates the results, were undertaken at the request of the Turkish Government, with the view of placing lights at the entrance of the Bosphorus from the Black Sea. The object of his inquiry is to investigate the principles on which the illuminating power, resulting from the employment of reflectors, and of lenses, depends; and the most advantageous application of that power to the purposes of Light-houses.

In discussing the relation which exists between the illuminating power and the intensity of an artificial light, he observes that the former is proportional to the quantity of light projected on a given surface at a given distance; and that the latter is dependent on the quantity of light projected by a given area of the luminous body on a given surface at a given distance. Hence the intensity of a light multiplied into its surface is the measure of the illuminating power, whether the light proceed from one or from several luminous bodies: and the illuminating power is equal to that of a sphere of light, whose intensity and apparent surface are equal to that of the light itself at any given mean distance.

Within a certain limit of distance, the property of light which produces the strongest impression on the eye, is its intensity; but when the light is so remote that the angle subtended by it at the eye is very minute, as is generally the case in Light-houses, the intensity of the impression made on the retina is proportional only to the illuminating power. The mathematical investigations of the author lead him to the conclusion that all reflectors and lenses of the same diameter have the same illuminating power when illuminated by the same lamp; and that by diminishing the focal distance, and intercepting more rays, the illuminating power is not increased, but simply the divergence, and consequently the surface or space over which it acts. The author then proceeds to inquire into the comparative utility of lenses and reflectors, and arrives at the inference that the advantage gained by the employment of the former does not arise from their superior perfection as optical instruments, but from their using the light more economically, in consequence of their producing less divergence of the rays, both horizontally and vertically, and illuminating a much smaller space in the horizon. Rules are then deduced for the application of lenses and reflectors in Light-houses, according to the particular situations in which they are placed, and the purposes they are intended to

serve. With this view, the author divides Light-houses into three classes: the first comprising Beacon or Warning Lights, placed in order to prevent the approach of vessels, and which consequently can never be nearer than three or four miles; the second being Guiding or Leading Lights, placed to guide a vessel, and therefore admitting of a very near approach; and the third including those which, according to the respective directions in which they are seen, have both these duties to fulfil. In the first we require great illuminating power, and a long duration of the brightest period, with a small angle of vertical divergence; in the second, less illuminating power, but a larger angle of vertical divergence are requisite, while the duration of the extreme brightness is of minor importance; and in the third, all these properties, namely, great illuminating power, a long duration of the brightest period, and a large angle of vertical divergence, are necessary.

May 11, 1837.

WILLIAM LAWRENCE, Esq., V.P., in the Chair.

Henry S. Boase, M.D., and William Tierney Clark, Esq., were elected Fellows of the Society.

A paper was in part read, entitled, "On the connexion between the Phenomena of the absorption of Light and the Colours of thin Plates." By Sir David Brewster, K.H., F.R.S.

The Society then adjourned over the Whitsun week, to meet again on the 25th instant.

May 25, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

The Rev. William Walton and Richard Westmacott, jun., Esq., were elected Fellows of the Society.

Sir David Brewster's paper was resumed and concluded.

The phenomena of the absorption of light by coloured media have been regarded by modern philosophers as inexplicable on the theory of the colours of thin plates, and therefore irreconcilable with the Newtonian hypothesis, that the colours of natural bodies are dependent on the same causes as the colours of thin plates. The discovery by Mr. Horner of a peculiar nacreous substance possessing remarkable optical properties, of which the author has already given an account, furnished him with the means of instituting a more accurate comparison between these two classes of phenomena. By a careful and minute analysis of the reflected tints of its first three orders of colours exhibited by a single film of the above-mentioned substance, they were found to consist of that part of the spectrum which gives the predominating colour of the tint mixed with the rays on each side of it. In analysing the transmitted beam, bands of the colours complementary to the former are seen, with intervening dark bands; and when the analysis is made with a high magnifying power, the

spectrum is observed to be crossed throughout its whole extent with alternate dark and coloured bands, increasing in number and diminishing in magnitude with the thickness of its plate. In the phenomena of periodical colours there are three peculiarities demanding notice; first, that the dark lines change their places by varying the inclination of the plate; secondly, that two or more lines never coalesce into one; and thirdly, that the colour of the luminous bands in the complementary spectrum are the same as those of the original spectrum when the thin plate is perfectly colourless. The author institutes a comparison of these phenomena with those of absorption as exhibited by a solid, a fluid, and a gaseous body; employing as an example of the first, smalt blue glass; of the second, the green sap of vegetables; and of the third, nitrous acid gas. No connecting link between these phenomena appeared to exist, excepting that both exhibited a divided or mutilated spectrum; but even this common fact has not the same character in both. The nacreous substance described by Mr. Horner, however, in some cases, when the plates were small, was found to produce bands perfectly identical with those of thin plates; while in other cases the bands were exactly similar to those of coloured media. By employing the iridescent films of decomposed glass, the author obtained combinations of films which gave, by transmitted light, the most rich and splendid colours, surpassing every thing he had previously seen among the colours either of nature or of art. These facts have proved that the transmitted colours, though wholly unlike those of thin plates, are yet produced by the same causes, and are residuary, and generally complementary to the sum of the reflected tints. Thus the author has succeeded in completely identifying in their primary features the two classes of facts; the one resulting from absorption, the other from periodic action. The minor points of difference, namely, the uniformity of the bands and tints of absorbing media at all incidences, and the non-appearance of the reflected tints in such media, are endeavoured to be explained by the introduction of several considerations, the complete discussion of which the author reserves for the subject of a future paper. From the phenomena of thin plates, of polarized tints, and of absorption, the existence of a new property of light is deduced, in virtue of which the reflecting force selects out of differently coloured rays of the same refrangibility rays of a particular colour, allowing the others to pass into the transmitted ray; a principle not provided for in either of the theories of light to which the phenomena of absorption are ultimately referable, and furnishing an explanation of certain remarkable phenomena of dichroism in doubly refracting bodies, in which rays of the same refrangibility, but of different colours, pass into the ordinary and extraordinary pencils.

A paper was read "On the hereditary instinctive propensities of Animals." By Thomas Andrew Knight, Esq., F.R.S.

The author adduces, in support of the principle he had advanced in his paper on the economy of bees, namely, that instinctive propensities to the performance of certain actions are transmitted, inde-

pendently of education, from the parent to its offspring, several facts which have fallen under his observation in the course of various experiments commenced by him nearly sixty years ago and continued to the present time. He relates that a young terrier, whose parents had been trained to destroy pole-cats, and a young springing spaniel, whose ancestors through many generations had been employed in finding woodcocks, were reared together as companions; and that each of them, immediately on seeing, and for the first time in its life, the particular prey to which it was guided by hereditary instinct, pursued it with intense eagerness, while it did not appear to notice that which attracted its companion. In several instances he found that young springing spaniels, wholly inexperienced, were very nearly as expert in finding woodcocks as their well-trained parents. The habits of the woodcock have in the course of the last sixty years undergone considerable change, the fear of man having during that period become much stronger by transmission through many successive generations. The author believes that by continued education these hereditary propensities might be suppressed and others substituted: thus the habits of the springing spaniel would never have been acquired, if shooting on the wing had not been practised by man. A young dog, of the variety usually called *retrievers*, on account of their being trained to find and recover wounded game, performed this office, although wholly untaught, quite as well as the best-instructed dog. The male and the female parents appear to possess similar powers of transmitting to their offspring these hereditary feelings and propensities; excepting in the case of hybrid progeny, in which the author thinks he has witnessed a decided prevalence of the character of the male parent. With regard to dogs, the influence of one or other of the parents, and sometimes of both, may occasionally be traced, but without any constancy as to the particular predominance of either sex.

A paper was read "On Meteorological deductions from Observations made at the Observatory at Port Louis in the Mauritius, during the years 1833, 1834, and 1835." By John Augustus Lloyd, Esq., Surveyor-General of that Island, F.R.S. Communicated by Captain Beaufort, R.N., Hydrographer to the Admiralty, F.R.S.

The observations, from which the results recorded in the present paper were made, are nearly 50,000 in number, and were taken four times each day, at the hours of 8 A.M. noon, 4 and 8 P.M. The details of the observations themselves are about to be forwarded to the Royal Society; they relate to the states of the barometer, thermometer, hygrometer, rain gauge, and the appearance of the atmosphere with regard to clearness or cloudiness.

June 1, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

William Ayrton, Esq., James Carson, M.D., William Hopkins, Esq., M.A., and Captain John Thomas Smith, were severally elected Fellows of the Society.

A paper was read, entitled, "On the development and extinction of regular doubly refracting structures in the crystalline lenses of animals after death." By Sir David Brewster, K.H., L.L.D., F.R.S.

Since the year 1816, when the author communicated to the Royal Society an account of the doubly refracting structures which exist in the crystalline lenses of fishes and other animals, he has examined a great variety of recent lenses with the view of ascertaining the origin of these structures, the order of their succession in different lenses, and the purpose which they answer in the animal economy. He had discovered in the lenses of many fishes the alternation of portions, exerting, the one a positive, and the other a negative refractive action; but in his subsequent investigations he met with the greatest discrepancy as to the regularity of their arrangement. He found that in quadrupeds the central structure is positive; while in fishes, where there are three structures, it is always negative; but their positive structure in the former case sometimes exists alone, with faint traces of a negative structure, and sometimes it is followed by another positive structure separated from the first by a black neutral circle, in which the double refraction disappears; at other times various other combinations of these structures are presented. Occasionally, in the dark neutral line which separated two positive structures, he perceived a trace of an intervening structure, which seemed to be either about to disappear or about to be developed. This conjecture was satisfactorily verified by a series of observations which he made on the lenses of the sheep, the ox, and the horse, at different ages, and also on the same lens, during the spontaneous changes it undergoes when kept in distilled water. The negative structure was in these experiments gradually developed at the space intervening between the portions of the lens which had possessed the positive structure; and thus the same parts assumed in succession doubly refractive actions of opposite kinds. The author intimates his intention of pointing out, in a separate paper, the conclusions deducible from these facts respecting the cause and cure of cataract.

June 8, 1837.

WILLIAM LAWRENCE, Esq., V.P., in the Chair.

Robert Bigsby, Esq., George Edward Frere, Esq., and Captain Joseph Ellison Portlock, R.E., were elected Fellows of the Society.

A paper was in part read, entitled "Observations on the minute structure of the higher forms of Polypi, with observations on their classification." By Arthur Farre, M.B. Communicated by Richard Owen, Esq., F.R.S.

June 15, 1837.

FRANCIS BAILY, Esq., V.P. and Treasurer, in the Chair.

James F. W. Johnston, Esq., A.M., was elected a Fellow of the Society.

The following papers were then read, viz.:

"Observations on the minute structure of some of the higher forms of Polypi, with views of a more natural arrangement of the class." By Arthur Farre, M.B., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. Communicated by Richard Owen, Esq., F.R.S., was resumed and concluded.

After a short account of the labours of preceding naturalists in that department of zoology which comprises the various kinds of polypes, and of the different characters on which they have founded the classification of these animals, the author proceeds to the statement of his own observations on several species which had not been previously investigated with sufficient minuteness and care. Two of the species described he believes to be entirely new, and he has accordingly given them the names of *Bowerbankia densa*, and *Lagenella repens*. The other species which are the subject of the author's investigation, are *Vesicularia spinosa*, *Valkeria cuscuta*, *Alcyonidium diaphanum*, *Membranipora pilosa*, and *Notania lorica*.

He then discusses the principles on which the classification of this tribe of zoophytes should be founded, and proposes on these principles to give the name of *Cilisbrachiata* to the whole group of polypes characterised by the possession of ciliated tentacula, and a free alimentary canal with two orifices: this group again he divides into two subordinate groups, namely, the *Hydriform* and the *Actiniform*, or *Zoanthiform* polypes. Under the title of *Nudibrachiata* he proposes to comprehend all those polypes which partake of the nature of the hydra, and whose tentacula are unprovided with cilia, corresponding to the *Anthozoa* of Ehrenberg.

"On the Temperature of Insects, and its connexion with the functions of Respiration and Circulation." By George Newport, Esq. Communicated by P. M. Roget, M.D., F.R.S.

The author states at the commencement of his paper, that, although it has been long known that insects living in society, as the bee and the ant, maintain in their habitations a temperature higher than that of the open air, the fact had never yet been established that individual insects of every kind possess a more elevated temperature than that of the medium in which they reside, and that in each species the degree of elevation varies in the different stages of their existence. He was first led to study the temperature of insects in consequence of the curious results which he had met with in some observations he had himself made, in the autumn of the year 1832, on a species of wild bee in its natural haunts, with a view to ascertain, as had been suggested to him by Dr. Marshall Hall, the relation between the temperature of these insects during their hybernation, and the irritability of their muscular fibre: but the fact of the existence of a higher temperature in individual insects had been ascertained by himself prior to these observations; the results of which observations, together with other facts connected with the physiology of insects, he subsequently communicated to Dr. M. Hall.

Since the time when the author has been engaged in the prosecution of this inquiry, some observations on the same subject have been published by Dr. Berthold, of Göttingen, who expresses it as his opinion that insects ought not to be regarded as cold-blooded animals, but who does not appear to have detected the existence of a temperature higher than the surrounding medium in any individual insect. The author also notices the observations on this subject made by Hansmann, Juch, Rengger, Dr. John Davy, and others, some of whom have detected, while others have not observed, the existence of an increased temperature in this class of animals. He then gives a detailed account of the precautions to be taken for ensuring accuracy in making observations of this kind; and remarks that greater reliance is to be placed on those made on the external than on the internal temperature of the animal, seeing that comparative results are all that can be obtained, and that the injury inflicted on the insect by its mutilation very materially interferes with the correctness of the conclusions as to the degree of internal temperature.

After premising these introductory remarks, the author gives a detailed account of his observations on the temperature of insects in their several states of larva, pupa, and imago, from which it appears that those which possess the highest temperature are always volant insects, and are chiefly diurnal species, residing almost constantly in the open air. He shows that the larva has a lower temperature than the imago, and that the energy of its respiration is also less, regard being had to the activity of the insect, and to the size of its body. In lepidopterous insects the average elevation of temperature above that of its surrounding medium, is in the larva from $0^{\circ}9$ to $1^{\circ}5$; while in the imago it is from 5° to 10° . Among the hymenoptera it is from 2° to 4° in the larva, and in the imago from 4° to 15° or even 20° ; but in all cases the amount of this elevation is shown to depend on the degree of activity, and the quantity of air respired during a given period. The author then inquires into the influence of various circumstances, such as inactivity, sleep, hybernation, and inordinate excitement, on the temperature of insects; and shows that the evolution of heat gradually diminishes in a degree corresponding to the length of time during which the insect remains in a state of repose, but that it is immediately increased as soon as the insect is roused into action. He adverts also to the remote cause of hybernation, which he ascribes, in every state of the insect, to accumulations of adipose matter, or of nutrient fluid, which, being stored up in the system, induce a plethoric state, from which the animal is aroused when this store of materials has been exhausted. A variety of experiments are related, tending to prove that a large proportion of the heat evolved by an insect, when in a state of great activity, is dissipated into the surrounding medium, and that the quantity of heat so generated bears definite relations to the habits, the locality, and the energy of respiration in each respective species of insect. Volant insects, he finds, have the highest temperature; and of these the diurnal bear a higher temperature than the crepuscular; next

to these must be placed the diurnal terrestrial, and last of all the nocturnal terrestrial species.

In the next division of this paper the author considers the temperature of those insects which live in societies; and in particular of the humble bee and the hive-bee. His observations are confirmatory of many of those of Huber relating to the incubating habits of the former of these species; and he has farther ascertained that during the act of incubation the bees possess a voluntary power of generating heat, whereby the temperature of their bodies is raised, apparently for the purpose of imparting warmth to the young in the cells; that this process is accompanied by accelerated respiration; and that the amount of heat evolved is proportional to the quantity of air respired. The law established by Dr. Edwards in the case of the young of mammiferous animals, namely, that they possess less power of generating heat, and that for a certain time they are unable to maintain their usual temperature, is shown by the author to be equally applicable to the early stage of insect life, and also to the perfect insect immediately after its developement from the pupa.

The temperature of the hive-bee is next examined, and it is shown, contrary to the statements of Reaumur, Huber, and others, that bees do not maintain a very high temperature in their hives during winter, but that they are disposed, when not disturbed by any occasional vicissitudes of atmospheric temperature, to assume the state of hibernation; although, on the other hand, when the bees are much disturbed, the temperature of the hive may, even in the midst of winter, become greatly raised. The temperature of the hive is lowest in January, and gradually increases up to the period of swarming, in May or June, after which time it diminishes. A table is given exhibiting the results of successive observations on the influence of the diminution of heat and of light which attended the progress of the annular eclipse of the sun on the 15th of May, 1836, on the temperature of the hive.

It appears from the inquiries of the author that different parts of the hive do not preserve the same relative heat among one another at different periods, and also that the amount of free heat in the hive is often 10° or 15° , even in the months of July and August.

The remaining division of the paper is devoted to the consideration of the connexion existing between the developement of heat and the functions of respiration, circulation, and digestion. The state of the pulse during all the different stages of the larva until its metamorphosis into the pupa is examined with great minuteness, and the results are given in a tabular form. The author traces the rate of pulsation during different conditions of repose and activity, and the corresponding frequency of respirations, and finds that although there is a general accordance between the activity of these two functions, yet that the activity of respiration and the quantity of heat evolved do not depend primarily on the velocity of the circulation, but that under all circumstances the quantity of heat developed is exactly proportional to the quantity of respiration. While the insect is feeding, and digestion is going on, the evolution of

heat increases, and while it is fasting it diminishes; but this diminution has a limit, whereas increased respiration is invariably attended by increased heat. Gaseous matter is exhaled in great abundance from the surface of the body of an insect, and contributes to regulate and equalize its temperature; but the quantity diminishes in proportion to the length of time during which it has been deprived of food. The author maintains that animal heat is not an effect of mere nervous influence, either general or ganglionic; an opinion which he derives from the following considerations: first, that in many insects in which considerable degrees of heat are evolved, and the respiration is energetic, the nervous system is small compared with that of others in which the respiration is less vigorous; and secondly, that if the evolution of animal heat were dependent on the existence of ganglia, the leech ought to generate more heat than the larva of the Lepidoptera, since it has a much greater number of ganglia. Hence he is disposed to draw the general conclusion that animal heat results directly from the changes which take place during respiration; and that the reason why so large a quantity passes off so rapidly from the body of an insect is because it does not become latent, since the circulating fluid, unlike what takes place in the higher animals, is neither completely venous nor completely arterial, but of a character intermediate between both.

Twenty-one tables are annexed exhibiting the records of the experiments referred to in the paper on the respiration, temperature, and circulation of insects.

“Observations on the Dry-rot of Ships, and an effectual method to prevent it pointed out.” By James Mease, M.D. Communicated by Charles Konig, Esq., For. Sec. R.S.

The method recommended by the author for preventing the occurrence of the dry-rot in ships is to impregnate the timbers and planks with common salt, as is practised by the ship-builders in Philadelphia. For this purpose all the spaces between the timbers and the outside and inside planks are to be filled with Spanish or Portugal salt, driven down as the filling proceeds. The salt is found to penetrate thoroughly, and completely to saturate the wood, combining with its native sap and preventing fermentation and the consequent evolution of foul air. The principal inconvenience attending this method is the dampness of the ships; an evil for which the author suggests various remedies.

“Experimental Researches on the conducting powers of wires for Electricity; and on the heat developed in metallic and liquid conductors.” By the Rev. William Ritchie, L.L.D., Professor of Natural Philosophy in the Royal Institution of Great Britain, and of Natural Philosophy and Astronomy in University College, London.

In a former communication, published in the Philosophical Transactions for 1833, the author endeavoured to show that the quantity of voltaic electricity conducted, or the force of the current, was a function of a greater number of variables than had been previously

supposed. As the theory which he proposed for estimating the conducting powers of substances has been controverted by M. Lenz, he has been induced to reconsider the subject, and finds reason to be satisfied with the correctness of his former views. He farther finds that with feeble magnetic needles the deflecting forces are not proportional to the force of the current, but approach nearer and nearer to that proportion by increasing the magnetic power of the needles ; a result which the author thinks is strictly deducible from the universal law of nature, that the attraction mutually exerted by two bodies is measured by the sum of their masses. He shows that the formula of Ohen, expressive of the conducting powers of wires, and of the resistances which they offer to currents of voltaic electricity, is an approximation to the truth only in the case of feeble currents, and that with the same metal, the conducting powers are not as the lengths of the wires.

The author next inquires into the relation between the heat developed, which he finds to be, in the same wire, as the square of the intensity of the current ; and in wires of the same diameter, and conducting equal quantities of electricity, it is inversely as the conducting power, or directly as the resistance which they oppose to the current. The facts he has adduced in this paper seem to be at variance with the generally received theory of caloric, and to be in perfect accordance with the undulatory theory.

He concludes by describing an experiment confirming the views he has elsewhere advanced with regard to the difference between the physical, the physiological, and the chemical effects resulting from the employment of coils formed of wires of different lengths, being dependent on the time required by the conductor for returning to its natural state.

“ On the Ipoh or Upas poison used by the Jacoons and other aboriginal tribes of the Malayan Peninsula.” By Lieut. T. S. Newbold, Aide-de-Camp to Brigadier-General Wilson, C.B. Communicated by P. M. Roget, M.D., Sec. R.S.

The author gives an account of the process by which the Jacoons, an aboriginal tribe inhabiting the mountains and forests of the Malayan Peninsula, prepare the poison applied to the points of the slender arrows which are propelled from the *Simpitan* or blow-pipe. Three preparations are employed for this purpose, distinguished by the names of *Krohi*, *Tennik* or *Kennik*, and *Mallaye* ; the last of these is more powerful than the other two, and is obtained from the roots of the *Tuba*, the *Perachi*, the *Kopah*, and the *Chey*, and from that of the shrub *Mallaye*, whence it derives its name. The *Krohi* poison is prepared from the root and bark of the *Spoh* tree, and the roots of the *Tuba* and *Kopah*, with the addition of red arsenic and the juice of limes ; and the *Tennik* from the same ingredients, omitting the *Kopah* root. A few experiments are related, made by the author with a view to ascertain the effects of the poisoned arrows on living animals, from which it appears that the train of symptoms commence in a few minutes after the infliction of the wound, and

terminate fatally with more or less rapidity, according to the size of the animal.

"Della Velocità del Vento. Memoria diretta alla Regali Società di Londra per essere inscritta nelle Transazioni filosofiche, et pel concorso del premio annuale di fisica: di Luigi Dau, Dottore in Matematica e Fisica." Communicated by Charles Konig, Esq. For. Sec. R.S.

The author endeavours to investigate the relation which he believes exists between the velocity of the wind and the oscillations of the barometer, and thence to derive rules for calculating the former from observations of the latter.

"Considérations physiques sur le passage Nord-ouest;" by the same. Communicated by the Right Hon. the Earl of Minto, G.C.B. F.R.S.

The author of this memoir, considering that the practicability of a North-west Arctic passage must depend on the mean summer atmospheric temperature of the most northern point of the continent of America being above that at which the congelation of sea water takes place, applies himself to the determination of these temperatures. The results of his calculations are given in a table, exhibiting the extreme and the mean temperatures of the atmosphere for each of the summer months, from May to September, at all degrees of latitude, from 60° to 80° inclusive. According to this table, the temperature of zero, which is about the freezing point of sea water, prevails, at 60° of latitude, on the 10th of May; at 61° lat. on the 20th of May; at 63° , on the 1st of June; at 65° , on the 10th of June; at 67° , on the 20th of June; and at 71° , during the whole of the months of July and August. The author concludes that navigators can reach, without danger of being obstructed by ice, the latitude of 71° during these latter months: and that since the American continent does not probably extend beyond 70° north latitude a passage to the North-west is then open. He recommends, however, that instead of attempting it by the dangerous navigation of the polar sea, a coasting voyage between the continent and the numerous islands which exist in that ocean should be undertaken; or, what he thinks still more promising of success, an expedition by land for exploring the country intervening between the Coppermine River and Hudson's Bay.

"Causes de la Variation diurne de l'Aiguille aimantée, de la Lumière zodiacale, des Aurores Boreales, et Méthode simplifiée pour le relevement des Longitudes, Mémoire soumis à la Société Royale de Londres, pour le concours du prix d'Astronomie. Par Demonville."

The author's speculations proceed on the hypothesis he has adopted, that the Sun, Moon, Jupiter and Mars perform a diurnal and perfectly circular revolution round the earth.

"On the elementary structure of the Muscular Fibre of Animal and Organic Life;" by Frederic C. Skey, Esq., Assistant Surgeon to St. Bartholomew's Hospital, F.R.S.

The author having withdrawn the paper bearing the same title

which he had formerly communicated, and which was read to the Society on the 9th and 16th of February last; and having made in it several alterations and additions, consisting chiefly in notices of the discoveries of preceding anatomists in the same field of inquiry, again presents it to the Society with these improvements.

“Sequel to an Essay on the Constitution of the Atmosphere published in the Philosophical Transactions for 1826; with some account of the Sulphurets of Lime;” by John Dalton, D.C.L., F.R.S.

The author communicates in this paper an account of the investigations on the constitution of the atmosphere, which have engaged his attention during a long period of years. He enters into an examination of the comparative advantages of the three methods which are most in use for analysing common air, namely, firing it with hydrogen in Volta's eudiometer, or abstracting the oxygen by means of nitrous gas and quadrisulphuret of lime; and details the precautions to be taken in the employment of each of these methods, and the degree of accuracy to be expected from the results under different circumstances. He then relates numerous experiments made on air obtained from great heights, from which he is led to the conclusion that the proportion of oxygen to azote in the atmosphere on the surface of the earth is not precisely the same at all places and times; and that in elevated regions this proportion is somewhat less than at the surface of the earth, but not nearly so much as the theory of mixed gases would require, and that the reason for this is to be found in the incessant agitation of the atmosphere produced by winds and other causes.

“Researches on the Tides. Eighth Series. On the progress of the Diurnal Inequality-wave along the coasts of Europe.” By the Rev. William Whewell, F.R.S., &c.

In the seventh series of these researches, the author pointed out the laws which the diurnal inequality of the height of high water follows, and showed that those laws are modified so as to exhibit very remarkable differences at different places, and to occasion some difficulty in conceiving the mechanical propagation of the tide-wave. He then suggested what appeared to be a possible solution of the difficulty; but as this suggestion was founded on facts from a few places only, he resolved to attempt to trace the progress of the wave which brings the diurnal inequality on some of the coasts, on which simultaneous observations were made at his request in June 1835; and the present memoir contains an account of the conclusions to which he has been led by this investigation. The details which he gives of the observations made, with this view, at nineteen different stations, appear to establish the conclusion, that the differences of diurnal inequalities at different places are governed by local circumstances, and do not form a progressive series.

“Note on the Fluctuations of the Height of High-water due to changes in the Atmospheric Pressure.” By J. W. Lubbock, Esq., F.R.S.

The author verified, both at Liverpool and at London, the existence of a fact similar to that which M. Daussy had ascertained at Brest, namely, the rise of the ocean when the barometer is depressed; and remarks that the correction due to changes in the atmospheric pressure is by no means inconsiderable. He suggests the question whether the surface of the ocean rises in narrow seas simultaneously with the depression of the barometer, or otherwise. With a view to the solution of this question, he gives a tabular diagram showing the correspondence between the calculated and the observed heights, in their relation to the heights of the barometer at Liverpool and at London, from which it would appear that the effect of changes in the atmospheric pressure on the tide is immediate.

“On an improved mode of constructing Magnets.” By James Cunningham, Esq., Member of the Cork Scientific and Literary Society. Communicated by North Ludlow Beamish, Esq., F.R.S., President of that Society.

The material recommended by the author for the most economical, as well as effectual method of constructing magnets, is cast iron, which should be formed in small castings in the form of a horse-shoe, each weighing about seven ounces; these he finds, on being touched in the usual manner by a small compound magnet, received and retained the impregnation better than any which he had previously constructed of steel.

The Society then adjourned over the long vacation, to meet again on the 16th of November next.

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